5

S.V. 24

University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 2. No. 10

SEPTEMBER, 1890

BUILDING STONE IN NEW YORK

BY

JOHN C. SMOCK

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1890

Regents

George William Curtis, LL. D., L. H. D., *Chancellor*
Anson J. Upson, D. D., LL. D., *Vice-Chancellor*

David B. Hill, Governor Edward F. Jones, Lieutenant-Governor Frank Rice, Secretary of State Andrew S. Draper, LL. D., Sup't of Pub. Instruc.	*Ex-officio*

In order of election by the legislature

George William Curtis, LL. D., 1864	West New Brighton
Francis Kernan, LL. D., 1870	Utica
Martin I. Townsend, LL. D., 1873	Troy
Anson J. Upson, D. D., LL. D., 1874	Glens Falls
William L. Bostwick, 1876	Ithaca
Chauncey M. Depew, LL. D., 1877	New York
Charles E. Fitch, 1877	Rochester
Orris H. Warren, D. D., 1877	Syracuse
Leslie W. Russell, LL. D., 1878	New York
Whitelaw Reid, 1878	New York
William H. Watson, M. D., 1881	Utica
Henry E. Turner, 1881	Lowville
St Clair McKelway, LL. D., 1883	Brooklyn
Hamilton Harris, 1885	Albany
Daniel Beach, LL. D., 1885	Watkins
Willard A. Cobb, 1886	Lockport
Carroll E. Smith, 1888	Syracuse
Pliny T. Sexton, 1890	Palmyra
T. Guilford Smith, 1890	Buffalo

Melvil Dewey, M. A., *Secretary*	Albany
Albert B. Watkins, Ph. D., *Assistant Secretary*	Albany

Standing Committees for 1890

Incorporation — Chancellor Curtis; Regents Kernan, Townsend, Fitch, Turner.

State Library — Chancellor Curtis; the Secretary of State, Regents Fitch, Watson, McKelway.

State Museum — The Superintendent of Public Instruction; Regents Kernan, Harris, Beach, C. E. Smith.

Academic Examinations — Regent Warren; Vice-Chancellor Upson, the Superintendent of Public Instruction, Regents Bostwick, McKelway.

Degrees — Vice-Chancellor Upson; Regents Townsend, Watson, Harris, Cobb.

Legislation — The Lieutenant-Governor; the Superintendent of Public Instruction, Regent Turner.

Finance — Regent Bostwick; the Lieutenant-Governor, Regents Beach, Sexton, T. G. Smith.

SPECIAL COMMITTEES

University Extension — Regent Watson; Vice-Chancellor Upson, Regent C. E. Smith.

Higher Examinations and Degrees — Chancellor Curtis; Vice-Chancellor Upson, Regents Bostwick, Watson, Sexton.

University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 2. No. 10

SEPTEMBER, 1890

BUILDING STONE IN NEW YORK

BY

JOHN C. SMOCK

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1890

PREFATORY NOTE

A report on the quarry districts of New York, and on the location, extent, geological relations, statistics and ownership of the quarries of building stone, was published by the State Museum as bulletin No. 3, March, 1888.

The scope of the work, as planned originally, included a series of comparative physical tests, chemical analyses and microscopic examinations of representative stones; but owing to the incompleteness of the collections, these investigations were not made, and the preparation of a second bulletin on the building stone of the state was then announced. Soon after the issue of bulletin No. 3, a circular letter was sent out, calling attention to it, and requesting the correction of any errors in it, and soliciting additional information on the extent, location and statistics of the quarries, and on the markets and use of the stone in cities. Answers were received from many of the quarry owners and superintendents, affording valuable data for a second report.

The additional information thus obtained has been incorporated in the descriptive notes of the quarries, so far as space would permit.

The work of collecting proper specimens, which should be typical and represent the leading classes and varieties of building stone quarried in the state, was done by Professor Francis A. Wilber, of Rutgers college, New Brunswick, New Jersey, who was employed to make the chemical analyses and the comparative physical tests. This collection was made in the summer of 1889. The work in the laboratory was done in the following autumn and in the winter of 1889–90. For purposes of comparison a few extra-limital stones were put in the series.

The desirability of a larger number of tests and of stones from all of our leading quarries is so evident that reference to the fact is here sufficient. Want of time and the cost of making such tests prevented their extension. The results show that the state is possessed of great wealth in the variety and superior character of its building stones. They are as good as the best of any state or country. The use of stone, in construction, in our cities, was suggested by the numerous references of

quarrymen to notable buildings as examples of their stone. The cities of the state having a population over twenty thousand were visited in the latter part of 1889 and in the winter of 1889–90, and notes were collected on the kinds of stone in general use, and the extent to which it was employed for building, street work and other general constructive work. Valuable and interesting data were thus obtained from dealers in stone, architects, city engineers, and others. They have been used with the notes of my own personal observations, in the preparation of the section: On the use of building stone in cities. The subject is interesting and of great practical importance. The ephemeral nature of the greater part of our buildings, the use of combustible materials, the ill-advised selection of stone and the faulty methods in construction, dictated by a false economy, especially in the case of the more costly public structures, point to the urgent need of more knowledge of the nature and value of our own building material, and the great aggregate losses by fires emphasize this lesson. The aim in this bulletin, as in the first one on this subject, has been to make the notes and descriptions plain and serviceable to the people of the state, and to admit such observations and discussions only, as tended to that end.

In the preparation of the section on the use of stone in cities, the report of Dr. Alexis A. Julien of Columbia college, in the tenth volume of the Tenth United States Census, on building stone in New York, has been of the greatest service. The list on pages 309–316 is largely taken from his report.

Valuable suggestions were obtained from Prof. James Hall's Report on Building Stone, to the capitol commission, made in 1868; from Geo. P. Merrill's Handbook and Catalogue of the Building and Ornamental Stones in the United States National Museum; from Prof. N. H. Winchell's Report on the Geology of Minnesota; and from Dr. Thomas Egleston's Monograph on the Cause and Prevention of the Decay of Building Stone. The microscopic examinations were made by Prof. F. L. Nason, of New Brunswick, New Jersey.

Again, it is a pleasure to acknowledge my great indebtedness to the many quarry owners and superintendents who gave freely of their time and services, and without which aid the preparation of this bulletin would have been impossible.

JOHN C. SMOCK

STATE MUSEUM, ALBANY, *September*, 1890

CONTENTS

I.

INTRODUCTION

Classification and Arrangement

The classification of building stone may be geological, according to the formations whence it is obtained, and following the systems of rock classification, in which the mineralogical and chemical characters serve as the basis for division into species and varieties, or it may be architectural, in which the use determines the arrangement of all the common kinds of stone in a few large groups. A strictly geological classification according to the horizon or age of the formation is however somewhat arbitrary and artificial, as stones almost identical in composition may be found in formations which are of different ages. Sandstones and limestones, for example, occur in all ages. What may be called the architectural arrangement, as granites, marbles, freestones, flagging stones, etc., is open to the objection of being indefinite, confusing and unscientific.

The division into groups or classes and species or kinds, based upon differences in their mineralogical constitution, is scientific and practical within certain limits. The subdivisions may not all be readily identified by the practical worker, or evident to the unaided and untrained eye, but the larger classes of stone are recognized by all and at once. The acquaintance with the varieties in them is a matter of education. Although the arrangement according to geological horizon does not serve to mark the larger divisions, it is convenient in description, and particularly in so far as it is also geographical and indicative of the groups

of localities. It gives us, as it were, the *provinces* of occurrence in the greater classes. In New York, the lithological characteristics of some of the geological formations have been studied so carefully, and are so persistent and well-known that their rocks have become types. The typical Potsdam sandstone, the Medina sandstone, the Trenton limestone, are recognized by practical quarrymen as well as by geological experts. The geographical limits of some of these varieties coincide with the geological boundaries of the outcropping formations. And hence a geological map of the state shows their respective areas of occurrence.

The arrangement in this report is in accordance with the geological order under the several classes of rocks, which are as follows:

I. Crystalline Rocks.

1. Granites, gneisses, syenites, etc., etc.
2. Trap-rocks.
3. Limestones and marbles.

II. Fragmental Rocks.

1. Sandstones and conglomerates.
2. Slates.

In the general notes on the geological relations of the building stone of the state, and in the description of the quarry districts and localities the subdivisions under the head of Limestones are:

Calciferous
Chazy
Trenton
Niagara
Lower Helderberg
Upper Helderberg
Tully

And under Sandstones:

Potsdam
Hudson River
Oneida
Medina
Clinton
Hamilton
Portage
Chemung
Catskill
Triassic

The order of succession in the series of geological formations in New York is shown in the columnar section on pages 200 and 201. In the first column the longer eras of the geological time are given, Paleozoic, Mesozoic and Cenozoic. The second column has the subdivisions into the several ages, Cambrian, Silurian, etc. In the third, the further division into periods and epochs is given.* The fourth column exhibits by conventional signs the nature of the predominant types of rock belonging to the several subdivisions. And the names of these leading kinds are given in the last column.

* The term "formation" is used in this report as comprising the deposits laid down during the epoch, e. g., the Potsdam sandstone formation.

Era.	*Ages.*	*Epochs.*	*Rocks.*
CENOZOIC.	POST TERTIARY.	TERRACE. CHAMPLAIN.	Sands and Clays.
		GLACIAL.	Boulder Clays.
	TERTIARY.	TERTIARY.	Sands and Clays.
MESOZOIC.	CRETACEOUS.	CRETACEOUS.	Sands and Clays.
	TRIASSIC.	TRIASSIC.	Shales, Sandstones, and Conglomerates.
PALEOZOIC.	CARBONIFEROUS.	LOWER CARBONIFEROUS.	Sandstones, Shales, and Conglomerates.
	DEVONIAN.	CATSKILL.	Conglomerates, Shales, and Sandstones.
		CHEMUNG.	Shales. and Sandstones.
		ONEONTA.	Sandstones and Shales.
		PORTAGE.	Shales and Sandstones.
		HAMILTON.	Shales and Sandstones.
		UPPER HELDERBERG.	Limestones.
		ORISKANY.	Sandstones.

Era.	*Ages.*	*Epochs.*	*Rocks.*
PALEOZOIC.	SILURIAN.	LOWER HELDERBERG.	Limestones.
		ONONDAGA.	Marls. Shales. Waterlime.
		NIAGARA.	Limestones. Shales.
		CLINTON.	Sandstones. Limestones. Shales
		MEDINA. ONEIDA.	Sandstones. Shales. Conglomerates.
		HUDSON RIVER. UTICA.	Sandstones. Slates. Shales.
		TRENTON. { Trenton, Black River, Birdseye, Chazy.	Limestones.
		CALCIFEROUS.	Sandrock. Limestones.
	CAMBRIAN. (Taconic.)	POTSDAM. GEORGIA STATE.	Sandstones. Quartzites. Slates. Schists.
ARCHAEAN.		HURONIAN. LAURENTIAN.	Serpentines. Marbles. Gneisses. Granites. Cryst'l. Limestones

II.

GEOLOGICAL POSITION AND GEOGRAPHICAL DISTRIBUTION OF BUILDING STONE IN NEW YORK

I. Crystalline Rocks.

Under this head there are the rocks which consist of one mineral species, and are simple in composition, as the limestones and marbles; and the more complex aggregates, in which two or more minerals enter, as the granites, gneisses, syenites, traps and other compound rocks. Since rocks, unlike mineralogical species, do not have a definite chemical composition, this subdivision is not based upon sharply defined characters. It separates them however into two classes, which include many species and kinds, whose varieties by imperceptible gradations approximating one another in composition, are still sufficiently well marked, to be placed in one or the other of these divisions. There are many varieties in the latter or compound class, differing slightly from one another in mineralogical composition and arrangement. And comparatively few of them are of economic importance as building stone.

A further subdivision of the compound crystalline rocks is into massive and foliated, schistose, or bedded, according as they occur in beds or are unstratified. The importance of this division is evident, in the absence of lamination or layers, in the homogeneous nature, and in the larger size of blocks which are obtainable in the case of the massive rocks.

Granites, Gneisses, Syenites, Trap-Rocks and Norites.

1. **Granites.** Typical granite is a crystalline, granular mixture of feldspar, quartz and mica. In addition to these essential constituents, one or more accessory minerals may

be present. The more commonly occurring are: hornblende, pyroxene, epidote, garnet, tourmaline, magnetite, pyrite and graphite. And the character of the rock is often determined by the presence of these accessory constituents in quantity.

The chemical composition also varies from that of the average or typical kind. The mineralogical differences mark the varieties, thus there are: hornblende granite, biotite granite, tourmaline granite, etc.

The texture of the granites is determined by the aggregated minerals entering into their composition. And they vary from coarse-crystalline, in which the individual crystals may be an inch or more in length, to fine-crystalline and aphanitic, wherein the minerals are hardly visible to the eye. When the feldspar and quartz are in a letter-like arrangement, the rock is known as pegmatite or graphic granite. A porphyritic structure is produced by the occurrence of the feldspar, in well-developed crystals in the mass. In consequence of the wide variation due to the mode of arrangement of the mineral constituents, there is an equally great variety noticeable in the texture.

The color also is dependent upon the minerals. As feldspar is the predominant constituent it gives character to the mass, and the red varieties are so because of the red or pink feldspars in them, as in the case of the granite of Grindstone Island in the St. Lawrence. The shades of gray are due to the varying amount of dark-colored mica mixed with the feldspar and quartz; and the darker-colored varieties owe their color in most cases to hornblende or tourmaline which may be present.

The beauty, ease of working, durability and value of the granites for use in construction is related closely to their mineralogical composition. Their arrangement in the mass and their relative proportion determine the color and give beauty. The presence or absence of certain species influence the hardness and homogeneous nature and the consequent ease with which the stone can be dressed and polished. For

example the mica, if disposed in lines, gives a foliated-like structure and tends to produce what is known as rift, and the granite is more readily split in the planes of the mica than across them. Again, the mica flakes may be so large and irregularly massed that the surface is not susceptible of a uniform degree of polish. Hornblende, on account of its superior toughness, is less brittle than pyroxene under the polishing, and the hornblende granites are said to be preferred to those which contain pyroxene in quantity.

The more nearly alike in hardness and the more intimately interwoven the texture of the minerals, the more capable it is of receiving a good polish. And hence it follows that the very coarse-crystalline granites are not so well suited for ornamental work.

The enduring properties of granites vary with the nature of the minerals in their composition. Although popularly they are regarded as our most durable building stone, there are some notable exceptions, which are evident in the natural outcrops, where this rock is found decayed to the depth of 100 to 200 feet,—and in the active disintegration which is in progress in structures of the present century. Foliated varieties placed on edge in buildings, tend necessarily to scale under the sharp and great changes of temperature in our northern cities and towns. The more rapid decomposition of the micas makes those varieties in which they occur in large flakes or aggregations more liable to decay. The condition of the feldspar also is often such as to influence the durability. When kaolinized in part, it is an element of weakness rather than of strength. The presence of the easily decomposable varieties of pyrite is not only prejudicial to strength and durability but also to the beauty of the stone as soon as it begins to decay.

The term "granite" as used among builders and architects is not restricted to rock species of this name in geological nomenclature, but includes what are known as gneisses (foliated and bedded granites), syenite, gabbro and other crystal-

line rocks whose uses are the same. In fact, the similar adaptability and use have brought these latter species into the class of granites. For example, the Au Sable granite of Essex county is a gabbro. The term is applied in some cases to the diabases or trap-rocks, as the "granite quarries" of Staten Island. Syenite differs from granite in having more hornblende, with some plagioclase feldspar and mica and little or no quartz. It is massive and its occurrence is like that of granite. And the same general statements apply to its durability as to granite.

Another massive crystalline rock which is used in building is norite and consisting of labradorite and hypersthene, with some brown mica. It is a common rock in the Adirondack region and is known as a granite.

The massive crystalline rocks are of common occurrence in New York, but not in outcrops over extensive areas, excepting in the Adirondack region. Granites, syenites, pegmatites and other massive rocks are found in veins and dikes in the Highlands and in Westchester county; but there are no quarries opened in these out-crops. The so-called granites of the Hudson river quarries are, with the exception of that on Break Neck mountain, granitoid gneisses and syenite gneisses. The schistose class of crystalline rocks is developed extensively in the Highlands of the Hudson and in the border of the Adirondack region. On New York island and within the city limits the gneissic rocks have been quarried at many points. In Westchester county there are belts of gneiss and mica schist, in which quarries have been opened near Hastings; near Hartsdale, east of Yonkers; at Kensico; at Tarrytown and at Ganung's, west of Croton Falls. In Putnam county there are quarries near Peekskill; and near Cold Spring. West of the river there are quarries on Iona Island; at West Point; near Suffern's; at Ramapo; on Mt. Eve, near Florida; and, on Storm King Mt. near Cornwall. The out-crops of these schistose or foliated rocks are so numerous in the belt of the Hudson Highlands that quarries can be opened at many

points. And the supply of stone is inexhaustible. On the Hudson river between Peekskill and Fishkill there is a fine section exposed of these rocks. The Ramapo river valley, traversed by the N. Y., L. E. & W. railway, the Harlem and the New York City and Northern, extend into and cross the belt and afford transportation to New York city.

On the borders of the Adirondack region quarries have been opened in the towns of Wilton, Hadley and Greenfield in Saratoga county; at Whitehall, in Washington county; at Little Falls, in Herkimer county; and near Canton, in St. Lawrence county. The inaccessibility of much of this region and the distance from the large city markets have prevented the opening of more quarries in the gneissic rock borders of the Adirondacks.

Trap-Rocks

Trap-rock or trap is the common name given to a class of eruptive rocks because of a structural peculiarity, and has no distinctive significance in mineralogical composition. The rocks of the Palisade mountain range and of the Torne mountain, which extends from the New Jersey line, on the west shore of the Hudson river to Haverstraw, are known as trap-rocks. There is an outcrop on Staten Island, near the north shore, where a large amount of stone has been quarried at the so-called "granite quarries."

The trap-rock of the Palisades range is a crystalline, granular mass of a plagioclose feldspar (labradorite usually) augite and magnetite. It is generally finer-crystalline than the granite. The colors vary from dark gray through dark green and almost black.

This trap-rock is hard and tough, but some of it is split readily into blocks for paving. It has been used extensively in New York and adjacent cities for street paving, but since the introduction of granite blocks this use has nearly ceased. On account of its toughness it makes an admirable material for macadamizing roadways. It is so hard that only rock-face blocks are used in constructive work. Several prominent

buildings in Jersey City and Hoboken are built of it. There is a large quarry on the river at Rockland lake, the output of which is for street work and road material almost exclusively.

Limestones and Marbles

Limestones consist essentially of calcium carbonate. They are however often quite impure; and the more common accessory constituents are silica, clay, oxides of iron, magnesia, and bituminous matter. And these foreign materials may enter into their composition to such an extent as to give character to the mass, and hence they are said to be siliceous, argillaceous, ferruginous, magnesian, dolomitic, and bituminous.

The chemical composition is subject to great variation, and there is an almost endless series of gradation between these various kinds or varieties. Thus, the magnesium carbonate may be present, from traces, to the full percentage of a typical dolomite. Or, the silica may range from the fractional percentage to the extreme limit where the stone becomes a calcareous sandstone. Crystallized minerals, as mica, quartz, talc, serpentine and others, also occur, particularly in the more crystalline limestones.

In color there is a wide variation — from the white of the more nearly pure carbonate of lime through gray, blue, yellow, red, brown, and to black. The color is dependent upon the impurities.

The texture also, varies greatly. All limestones exhibit a crystalline structure under the microscope, but to the unaided eye there are crystalline and massive varieties. And there are coarse-crystalline, fine-crystalline, and, sub-crystalline, according as the crystals are larger, smaller, or recognized by the aid of a magnifying glass only. The terms coarse-grained and fine-grained may apply when there is a resemblance to sandstone in the granular state of aggregation. Other terms, as saccharoidal (like sugar), oolitic,

when the mass resembles the roe of a fish; crinoidal, made up of the stems of fossil crinoids, also are in use, and which are descriptive of texture. The state of aggregation of the constituent particles varies greatly, and the stone is hard and compact, almost like chert, or is loosely held together and crumbles on slight pressure, or again it is dull and earthy as in chalk.

The crystalline, granular limestones, which are susceptible of a fine polish, and which are adapted to decorative work, are classed as marbles. Inasmuch as the distinction is in part based upon the use, it is not sharply defined and scientific. Generally the term is restricted to those limestones in which the sediments have been altered and so metamorphosed as to have a more or less crystalline texture. There is however some confusion in the use of the terms, and the same stone is known as marble and limestone, e. g., the Lockport limestone or marble; the limestone and coral-shell marble of Becraft's mountain, near Hudson; the Lepanto marble or limestone near Plattsburgh, and others.

The fossiliferous limestones are made up of the remains of organisms which have grown in situ, as for example, the coralline beds in the Helderberg and Niagara limestones, or have been deposited as marine sediments. In the case of the latter the fossils are more or less comminuted and held in a calcareous matrix. Generally the fossil portions of the mass are crystalline. The Onondaga gray limestone from near Syracuse, and the Lockport encrinital limestone are good examples.

The fossil remains are less prominent and scarcely visible in some of the common blue limestones, as in the lower beds of Calciferous and in some of the Helderberg series. These rocks are compact, homogeneous and apparently uncrystalline and unfossiliferous. They are usually more siliceous or argillaceous, that is, they contain quartz or clay, the latter often in seams rudely parallel with the bedding planes. On weathering, the difference in composition

is often markedly apparent at a glance. Similar differences in composition are seen in the more crystalline marbles, and are evident either by variation in color, or in the presence of foreign minerals, as mica, quartz, hornblende, pyrite, etc.

The variation in the strength and durability is as great as in the composition and texture. Some are stronger than many granites in their resistance to crushing force, and equally enduring; others consist of loosely cohering grains, and are friable and rapidly dissolved by atmospheric agencies. The more siliceous and compact limestones are generally the more durable and stronger; in the marbles, the well crystallized and more homogeneous texture consists with endurance and strength. Both the magnesian and dolomitic varieties are good stone as is proven by the Calciferous and the Niagara limestones, and in the marbles of Tuckahoe and Pleasantville, in Westchester county.

Crystalline limestones occur in New York city and Westchester county, and in the Highlands of the Hudson. In the Adirondack region there are numerous localities. The rock in many of them is too impure and has too many foreign minerals to admit of its use as marble. Quarries have been opened in Westchester, Putnam and Dutchess counties, which have yielded a large amount of fine white marble. In the northern part of the state, the Port Henry and the Gouverneur quarries have been productive. The geological horizon of some of these marbles is in doubt. The belt in the eastern part of Dutchess and Putnam counties belongs to the Vermont marble range, and is probably metamorphosed Trenton limestone. The Westchester marbles may be of the same age.

The limestones which furnish building stone in this state are the Calciferous, Chazy, Birdseye, Black River, Trenton, Niagara, Lower Helderberg, Upper Helderberg or Corniferous and Tully. The geographical distribution is given in the following notes, and in the order of geological succession, from the lowest to the highest.

Calciferous Sandrock

The rocks of the Calciferous formation in the Mohawk valley and in the Champlain valley are more siliceous than at the south-west, in Orange county and in the Hudson valley, and hence the designation as a sandrock. Much of it at the north is a limestone rather than a sandstone, and may be termed a magnesian or siliceo-magnesian limestone. Nearly all of the limestones, which are quarried for building stone, in Orange and Dutchess counties are from this formation. The stone occurs generally in thick and regular beds. It is hard, strong and durable and is adapted for heavy masonry as well as for fine cut work. The quarries near Warwick, Mapes' Corners and near Newburgh in Orange county and those on the Hudson river, near New Hamburgh, are in the Calciferous. The Sandy Hill quarry and those at Canajoharie and Little Falls are also in it.

Trenton Limestone

Under this head the Chazy, Birdseye, Black River and Trenton limestones are included.

The Chazy limestone crops out in Essex and Clinton counties and in the Champlain valley — its typical localities. The beds are thick and generally uneven. Regular systems of joints help the quarrymen in getting out large blocks. Quarries at Willsborough Point and near Plattsburgh are opened in the horizon of the Chazy. The stone is suitable for bridge work and for heavy masonry.

The members of the Trenton above the Chazy limestone are recognized in many outcrops in the south-eastern part of the state; in the Hudson-Champlain valley; in the Mohawk valley; in the valley of the Black river and north-west, bordering Lake Ontario; and in a border zone on the north of the Adirondacks, in the St. Lawrence valley. In so widely extended a formation there is, as might be expected, some variation in bedding, texture and color. Much

of the Trenton limestone formation proper, is thin-bedded and shaly and unfit for building stone. In the Birdseye also the stone of many localities is disfigured on weathering, by its peculiar fossils. Generally the stone is sub-crystalline, hard and compact and of a high specific gravity and dark-blue to gray in color. But the variation is wide, as for example, between the black marble of Glens Falls and the gray, crystalline rock of the Prospect quarries near Trenton Falls. The variation is often great within the range of a comparatively few feet vertically; and the same quarry may yield two or more varieties of building stone. In several quarries the Birdseye and Trenton are both represented. Many quarries have been opened in the formation and there are many more localities where stone has been taken from outcropping ledges, which are not developed into quarries proper. The more important localities which are worked steadily are: Glens Falls, Amsterdam, Tribes Hill, Canajoharie, Palatine Bridge and Prospect in the valley of the Mohawk; and Lowville, Watertown, Three Mile Bay, Chaumont and Ogdensburgh in the Black river and St. Lawrence valleys. The railroad and canal lines, which traverse the territory occupied by these formations, afford transportation facilities and offer inducements to those who are seeking new quarry sites where these limestones may be found in workable extent.

Niagara Limestone

The Niagara limestone formation is well developed west from Rochester to the Niagara river; and there are large quarries in it at Rochester, at Lockport and at Niagara Falls. The gray, sub-crystalline stone in thick beds is quarried for building purposes. It is filled with encrinital and coralline fossils and the unequal weathering of the matrix and the fossiliferous portions are sometimes such as to give the dressed surface a pitted appearance and with cavities which roughen and disfigure it. For foundations

and heavy masonry it is well adapted. And it has been employed extensively in the western part of the state.

Lower Helderberg Limestones

The Tentaculite, Water-lime and Pentamerus limestones are included in this group. The outcrops are in the Rondout valley, south-west from Kingston to the Delaware river; in the foot-hills east of the Catskills — in Ulster and Greene counties; Becraft's mountain near Hudson; and in a belt stretching west from the Hudson valley, along the Helderbergs and across Schoharie into Herkimer county.

The Tentaculite limestone is dark-colored, compact and in thick beds and can be quarried in large blocks. Some of it can be polished and makes a beautiful black marble, as for example, that of Schoharie.

The Pentamerus limestones, both the lower and the upper, are in thick beds and are gray, sub-crystalline in texture and look well when dressed. They are adapted to heavy masonry as well as for cut work.

Quarries are opened in this group of limestones in the Schoharie valley, at Howes Cave, Cobleskill, Cherry Valley and in Springfield. The quarries west of Catskill and in Becraft's mountain near Hudson also are in it.

Upper Helderberg Limestones

The Upper Helderberg formation appears in the Hudson valley at Kingston; thence it runs in a belt west of the river, to the Helderberg mountains, bending to the west-north-west and then west it continues across the state to the Niagara river and Lake Erie. The subdivisions are known as the Onondaga, the Corniferous and the Seneca limestones. The first is more generally recognized as the "Onondaga gray limestone" and the last as the Seneca blue limestone.

There is much diversity in the limestones of this group in its long range of outcrop. The Onondaga gray stone is

gray in color, coarse-crystalline ; and makes beautiful ashlar work, either as rock face or as fine-tooled, decorative pieces.

The Corniferous limestone is hard and durable, but it is so full of chert that it can be used for common, wall work only.

The Seneca blue limestone is easily dressed and is a fairly good building stone.

Limestone of the Upper Helderberg epoch is quarried extensively at Kingston, Ulster county, and is a valuable building stone. In Onondaga county there are the well-known Splitrock and Reservation groups of quarries, which have produced an immense quantity of excellent and beautiful stone and which have found a market in all of the central part of the state. They are in the lower member of the group. Going west, there are the large quarries in the Seneca limestone at Union Springs, Waterloo, Seneca Falls and Auburn. The LeRoy, Williamsville, Buffalo and Black Rock quarries are in the Corniferous limestone.

The aggregate output of the quarries in the Upper Helderberg limestones exceeds in value that of any other limestone formation in the state. The many quarries of the Trenton probably produce more stone.

Tully Limestone

The Tully limestone lying above the Hamilton shales, is a thin formation, which is seen in Onondaga county and to the west — on the shores of Cayuga lake — in Seneca county and disappearing in Ontario county. It does not furnish any stone other than for rough work and in the immediate neighborhood of its outcrops.

As a supplement to the limestones the quarry in calcareous tufa at Mohawk, in the Mohawk valley, should here be mentioned, although the quarry is of no importance and there is no great outcrop for much work in it.

II. Fragmental Rocks

Sandstones.

Sandstones are made up of grains of sand which are bound together by a cementing material, in a compact and consolidated mass.

The grains may be of varying sizes, from almost impalpable dust to small pebbles, and more or less rounded in form. The cementing matter also may vary greatly in its nature. From this variation, both in the grains and in the cement, there is an almost endless gradation in the kinds of sandstone.

Quartz is the essential constituent, but with it there may be feldspar, mica, calcite, pyrite, glauconite, clay or other minerals, and rock fragments common to stone of sedimentary origin. And these accessory materials often give character to the mass, and make a basis for a division into feldspathic, micaceous, calcareous sandstones, etc., according as one or another of them predominates.

The texture of the mass also is subject to a wide range of variation, from fine-grained, almost aphanitic, to pebbly sandstone, or conglomerate, or a brecciated stone in which the component parts are more or less angular.

Some of the brown sandstones of the Triassic age, quarried near Haverstraw, are such conglomeratic and brecciated sandstones. Accordingly as the grains are small or large the stone is said to be fine-grained or coarse-grained.

The variety in the nature of the cementing material also affords a basis for classification. Siliceous sandstones have the grains held together by silica. They consist almost exclusively of quartz, and grade into quartzite. The ferruginous varieties have for their cement an oxide of iron, often coating the grains and making a considerable percentage of the whole. The iron may be present as a ferrous oxide, or in the higher state of oxidation as ferric oxide. Calcareous

sandstones are marked by the presence of carbonate of lime. When it exceeds the quartz in amount the sandstone becomes a siliceous limestone. In the argillaceous varieties the binding material is a clay or an impure kaolin.

The cementing material determines in most cases the color. The various shades of red and yellow depend upon the iron oxides; some of the rich purple tints are said to be due to oxide of manganese.

The gray and blue tints are produced by iron in the form of ferrous oxide, or carbonate.* By an irregular association of masses of different colors a variegated surface is produced or by an alternation of white and variously colored laminæ a striped appearance is given to the mass.

Sandstones occur stratified and in beds of greater or less thickness, and they are said to be thick-bedded or thin-bedded. In some cases the beds are so thick and the stone of such a uniform texture, that the stone can be worked equally well in all directions, and is known as freestone. When fine-grained it is often designated as liver-rock. A laminated structure is common, and especially in the thin strata or when the stone is micaceous. When the beds can be split into thin slabs along planes parallel to the bedding it is called a flagstone. A less common structural character is what is termed lenticular or wedge-shaped, in which the upper and under surfaces lack parallelism, and the beds wedge out. It makes the quarrying more difficult, and produces more waste material.

These variations in the nature of the component grains, and binding material, in their arrangement and in the forms of bedding, produce a great variety of stone, and the gradations from one to another are slight. The hardness, strength, beauty and durability are determined by these varying elements of constitution. The hardness depends upon the quartz and the strength of the cement holding the grains or fragments together. Without the cement, or in

*W. G. Mann, Quart. Jour. Geol. Soc., Vol. xxiv, p. 355.

the loosely aggregated stone the grains are readily torn apart, and the mass falls with a blow,—a heap of sand. Generally the more siliceous the stone and the cement, the greater the degree of hardness and strength. The size, color and arrangement of the component grains are the elements which affect the appearance and give beauty to the sandstone. The durability is connected intimately with the physical constitution and the chemical composition. As a rule calcareous and clayey cementing materials are not as enduring as the siliceous and ferruginous. The stone best resisting the action of the atmospheric agencies is that in which the quartz is cemented by a siliceous paste, or in which the close-grained mass approaches in texture a quartzite.

The presence of minerals liable to decomposition, as feldspar, highly kaolinized, of mica, marcasite, and pyrite, of calcite in quantity, and clays, affects the durability and tends to its destruction.

Sandstones are classified according to their geological age also. They are found occurring in all the series, from the oldest to the most recent formations. And those of a given age are generally marked by characteristic properties, which serve for their identification, aside from the fossil organic remains by which their exact position in the geological series is fixed. This persistence in characters is exemplified in the Medina sandstones of the state, in the blue-stone of the Hudson river valley, and in those of the Triassic age or new red sandstone.

Sandstones are found occurring in workable quantity in all the greater divisions of the state, excepting the Adirondack region, and Long Island and Staten Island.*

Quarries have not however been opened everywhere in the sandstone formations, because of the abundant supplies of superior stone from favorably situated localities.

* There are isolated outcrops of brown sandstone and ferruginous conglomerate on Long Island, but not of any considerable extent or importance.

There are, in consequence, large sandstone areas and districts in which there is an absence of local development, or abandoned enterprises mark a change in conditions, which has affected injuriously the quarry industry in them.

Following the geological order of arrangement and beginning with the Potsdam sandstone, the several quarry districts are here reviewed briefly.

Potsdam Sandstone

This formation is the oldest in which, in this state, sandstone is quarried.*

The bottom beds are a fine, siliceous conglomerate ; above are sandstones and in thin beds generally. It is gray-white yellow, brown and red in color. In texture it varies from a strong, compact quartzitic rock to a loosely-coherent, coarse-granular mass, which crumbles at the touch.

Outcrops of limited area occur in Orange and Dutchess counties, and in the Mohawk valley. In the Champlain valley the formation is well developed at Fort Ann, Whitehall, Port Henry and Keeseville, and quarries are opened at these localities. The stone is a hard, quartzose rock, and in thin beds. North of the Adirondacks the formation stretches westward from Lake Champlain to the St. Lawrence ; and there are quarries in the towns of Malone, Bangor and Moira in Franklin county ; in Potsdam and Hammond in St. Lawrence county ; and, in Clayton, Jefferson county. In parts of Clinton county the stone is too friable for building uses.

The most extensive openings are near Potsdam, and the stone is hard, compact and even-grained, and pink to red in color. Some of it has a laminated structure and striped appearance. It is an excellent building stone and is widely known and esteemed for its beauty and durability.

* Some of the sandstones east of the Hudson and in the Taghanic range may belong to the Lower Cambrian. See Am. Jour. of Science, iii series, vol. 35, pp. 399–401. But there are no quarries opened in these localities.

The Hammond quarries produce a gray to red stone, nearly all of whose output is cut into paving blocks and street material.

Hudson River Group

The rocks of this group crop out in Orange county, north-west of the Highlands and in the valley of the Hudson river northward to the Champlain valley in Washington county. From the Hudson westward the Mohawk valley is partly occupied by them. The belt increases in breadth, thence in a north-west course across Oneida, Oswego and Lewis counties, and continues to Lake Ontario.

The rocks consist of shales and slates, sandstones and siliceous conglomerates. The slates are noticed under the heading slates, and in the notes on quarry districts.

The sandstones are generally fine-grained and of light gray or greenish-gray color. They are often argillaceous and not adapted for building purposes. But the even-bedded and well-marked jointed structure makes the quarrying comparatively easy, and the nearness to lines of transportation, and to the cities of the Hudson and Mohawk valleys have stimulated the opening of quarries at many points.

For common rubble work* and for local uses the quarries in this formation have furnished a large amount of stone. The more important quarrying centers are now at Rhinecliff on the Hudson, New Baltimore and Troy, in the Hudson valley; at Aqueduct, Schenectady and Duanesburgh, Schenectady county; Frankfort Hill, Oneida county; and in the town of Orwell, Otsego county.

These quarries have a local market and do not supply much, if any, stone to distant points. And nearly all of the stone is used in foundation and common wall work.

Oneida Conglomerate

This formation is developed to its greatest thickness in the Shawangunk mountain in Orange and Ulster counties.

* Prof. Amos Eaton gave the name of "rubble stone" to the sandstone in the upper part of the formation.

It is recognized in the Bellevale and Skunnemunk mountains, also in Orange county. In the central part of the state it is traced westward in a narrow belt from Herkimer county into Oneida county. The prevailing rocks are gray and reddish-gray, siliceous conglomerates and sandstones, which are noted for their hardness and durability. The cementing material is siliceous. The jagged edges and angular blocks and the polished and grooved surfaces of the glaciated ledges, so common on the Shawangunk range, afford the best proof of the durable nature of these rocks. The bottom beds, near the slate, contain some pyrite. No attempt has been made to open quarries for stone, excepting at a few localities for occasional use in common wall work. The grit rock was formerly quarried near the Esopus creek in Ulster county for millstones.*

The accessibility of the outcrops to the New York, Lake Erie and Western R. R., the N. Y., Ontario & Western R. R., the West Shore R. R., and the Del. & Hud. Canal lines is an advantage, as well as the comparative nearness to New York. And no other formation in the state exhibits in its outcrops better evidence of ability to resist weathering agents.

Medina Sandstone

The Medina sandstone is next above the Oneida conglomerate. It is recognized in the red and gray sandstones and the red and mottled (red and green) shales of the Shawangunk and Skunnemunk mountains in Orange county. A large amount of the red sandstone has been quarried on the north end of the Skunnemunk range, in the town of Cornwall, for bridge work on the railroads which cross the range near the quarry.

The red sandstone is seen exposed in the cuts of the Erie Railway northeast of Port Jervis. This formation reappears in Oswego county, and thence west to the Niagara river in a belt bordering Lake Ontario.

*Wm. W. Mather. Geology of the First Geological District, Albany, 1843, p. 357.

Prof. Hall describes it as follows: "The mass is usually a red or slightly variegated sandstone, solid and coherent in the eastern extremity of the district, becoming friable and marly in the western extension, and admitting an intercalated mass of gray quartzose sandstone, which contains marine shells; while in the red portions are rarely found other than marine vegetables or fucoids."*

Quartz is the principal mineral constitutent, associated with some kaolinized feldspar. The cementing material is mainly oxide of iron with less carbonate of lime. The stone is even-bedded and the strata dip gently southward. The prevailing systems of vertical joints, generally at right angles to one another, divide the beds into blocks, facilitating the labor of quarrying.

Quarries have been opened at Fulton, Granby and Oswego in Oswego county; at several points in Wayne county; at Rochester and on the Irondequoit creek, and at Brockport, Monroe county; at Holley, Hulberton, Hindsburgh, Albion, Medina and Shelby Basin in Orleans county; and at Lockport and Lewiston in Niagara county. The Medina sandstone district proper is restricted to the group of quarries from Brockport west to Lockport.

The leading varieties of stone are known as the Medina red stone, the white or gray Medina, and the variegated (red and white) or spotted. The quarries in this district are worked on an extensive scale, and their equipment is adequate to a large annual production. The aggregate output is larger and more valuable in dimension stone for dressing than that of any other quarry district in the state. And, including the stone for street work, the total value is greater than that obtained from the stone of any other geological formation in the state. The stone has gained a well-deserved reputation for its value as a beautiful and durable building material; and its more general employment both in construction and in paving is much to be desired.

* Survey of the Fourth Geological District by James Hall, Albany, 1843, p. 34.

The extent of the outcrops offers additional sites for quarrying operations, and the greater use of this stone, and the development of the producing capacity of the district are here suggested.

Clinton Group

The rocks of this group are shales, thin beds of limestone and shaly sandstones. They crop out in a narrow belt from Herkimer county west to the Niagara river and bordering the Medina sandstone on the south. Sandstone for building has been quarried in the southern part of Herkimer county; at Clinton, near Vernoa and at Higginsville in Oneida county, from this formation. The nearness of the Medina sandstone, with its more accessible quarries and superior stone, has prevented the more extensive development of the quarrying industry in the sandstone of the Clinton group.

Oriskany Sandstone

The Oriskany sandstone formation is best developed in Oneida and Otsego counties. The rock is hard, siliceous and cherty in places, and generally too friable to make a good building stone. And no quarries of more than a local importance are known in it.

Caudi Galli Grit and Schoharie Grit

These rocks are limited to Schoharie and Albany counties and to a very narrow belt which stretches south and thence south-west to Ulster county. The Caudi Galli sandstones are argillaceous and calcareous and are not durable. The Schoharie Grit is generally a fine-grained, calcareous sand-rock which also is unsuited for building. Quarries in these rocks can have local use only.

Marcellus Shale

As its name implies this formation is characterized by shaly rocks, which are not adapted to building. The

abundance of good building stone in the next geological member below it — the Corniferous limestone — whose outcrop borders it on the north throughout the central and western parts of the state, also prevents any use which might be made of its stone. The single quarry in it is at Chapinville, Ontario county.

Hamilton Group

The rocks of the Hamilton group crop out in a narrow belt which runs from the Delaware river, in a north-east course, across Sullivan and Ulster counties to the Hudson valley near Kingston; thence, north, in the foot-hills, bordering the Catskills to Albany county; then, bending to the north-west, and west across the Helderberg mountains into Schoharie county; thence, increasing in width, through Otsego, Madison and Onondaga counties, forming the upper part of the Susquehanna and Chenango watersheds; thence west, across Cayuga, Seneca, Ontario, Livingston, Genesee and Erie counties to Lake Erie. In this distance there is some variation in composition and texture. In the western and central parts of the state there is an immense development of shales and the few quarries in the sandstones referable to this group, are unimportant.* In the Helderbergs, in the Hudson valley and thence, south-west, to the Delaware river, the sandstones predominate and all of the beds are more sandy than at the west. And there is a great development of the bluish-gray, hard, compact, and even-bedded sandstone, which is known as "Hudson river bluestone," and is used so extensively as flagging. Some of the thicker beds yield stone for building also. The sandstone occurs interbedded irregularly with shales at most localities. The blue-stone or flag-stone beds are generally in the upper part of the Hamilton and they continue upwards in the horizon of the Oneonta sandstone, which may be the equiv-

*Geology of New York. Survey of the Fourth Geological District by James Hall, Albany, 1843, pp. 184–5.

alent of the Portage in the western part of the state.* The number of quarries in this blue-stone district, in Sullivan, Ulster, Greene, Albany and Schoharie counties is large and can be increased indefinitely, as nearly the whole area of the formation appears to be capable of producing stone for flagging or for building. The difficulty of indicating the division line between the Hamilton and the Oneonta and the Hamilton and the Portage group of rocks makes it impossible to refer to localities more particularly. The quarries near Cooperstown, in the lake region, particularly at Atwater, Trumansburgh, Watkins Glen and Penn Yan belong to the Hamilton group.

Portage Group

As stated above, the limits of the Oneonta at the east cannot be indicated and the flag-stone beds of the Hudson valley and of the eastern part of the state continue up into the Oneonta sandstone horizon. Many of the quarries are in the latter formation. The more western and north-western and higher quarries are in it; and some of the Chenango county quarries also.

The Portage rocks in the western part of the state have been divided into shales at the base; then shales and flag-stones; and the Portage sandstone at the top. In the last division thick beds with little shale are marks of this horizon. And the stone is generally fine-grained. The quarries near Portage and near Warsaw are in it; also the quarries at Laona and Westfield in Chautauqua county.

Although not of as great extent in its outcrop as the Hamilton group the Portage rocks are developed to a thickness of several hundreds of feet along the Genesee river at Mount Morris and at Portage; and form a belt having a breadth of several miles through Tompkins, Schuyler, Yates, Ontario and Livingston counties, and thence west to

*Palæontology of New York, vol. v, part I. Lamellibranchiata II, pp. 517-8.

Lake Erie.* And the formation is capable of supplying an immense amount of good building stone and flagging stone throughout its undeveloped territory.

Chemung Group

The rocks of the Chemung group crop out in the southern tier of counties, from Lake Erie eastward to the Susquehanna. The shales are in excess of the sandstones in many outcrops, and there is less good building stone than in the Portage horizon. The variation in color and texture is necessarily great in the extensive area occupied by the Chemung rocks, but the sandstones can be described as thin-bedded, generally intercalated with shaly strata, and of a light-gray color, often with a tinge of green or olive-colored. The outcropping ledges weather to a brownish color.† Owing to the shaly nature of much of the sandstone of the Chemung group, the selection of stone demands care, and the location of quarries where good stone may be found is attended with the outlay of time and money, and with great chances of possible failures. Quarries have been opened near towns and where there is a market for ordinary grades of common wall stone, and also for cut stone, but the larger part of their product is put into retaining walls. At Elmira and Corning good stone has been obtained, which is expensive to dress, and does not compete for fine work with sandstones from districts outside of the state. The quarries at Waverly, Owego, Elmira and Corning, and nearly all of the quarries in Allegany, Cattaraugus and Chautauqua counties are in the Chemung sandstone.

Catskill Group

As implied in the name, this formation is developed in the Catskill mountain plateau in the south-eastern part of the state. Sandstones and siliceous conglomerates predom-

---

* Report of Prof. Hall above cited, pp. 238–9.

† Prof. Hall's report on Fourth District (cited above), pp. 251, 252.

inate over the shales. The thicker beds of sandstones are generally marked by oblique lamination and cross-bedding, which make it difficult and expensive to work into dimension blocks. Except for flagging and stone for local use not much is quarried. There are no large towns in the district, and consequently the demand is light. There are however some good quarries, which are worked for flagging, chiefly along the N. Y., O. & W. R. R. and the U. & D. R. R. lines in Ulster and Delaware counties; and in the Catskills, in Greene county there are quarries in Lexington, Jewett, Windham, Hunter and Prattsville.

Triassic Formation

This formation, which is known as New Red Sandstone, or, locally, as the red sandstone, is limited to a triangular area in Rockland county, between Stony Point on the Hudson and the New Jersey line; and to a small outcrop on the north shore of Staten Island.

The sandstones are both shaly and siliceous, and the varieties grade into one another. Conglomerates of variegated shades of color also occur, interbedded with the shales and sandstones. And formerly these conglomerates were in favor for the construction of furnace hearths. They are not now quarried. The prevailing color of the sandstone is dark red to brown, whence the name "brownstone." In texture there is a wide variation, from fine conglomerates, in which the rounded grains are somewhat loosely aggregated, to the fine, shaly rock and the "liver rock" of the quarrymen. Oxide of iron and some carbonate of lime are the cementing materials in these sandstones.

The well-known Massachusetts Longmeadow sandstone, and the Connecticut brownstone, are obtained from quarries in the Connecticut valley region, and of the same geological horizon. The Little Falls, Belleville and Newark freestones are from the same formation in its south-west extension into New Jersey.

Quarries were opened in this sandstone more than a century ago, and many of the old houses of Rockland county are built of this stone. Prof. Mather reported thirty-one quarries on the bank of the Hudson near Nyack.* The principal market was New York city, and the stone was sold for flagging, house trimmings and common walls. The Nyack quarries have been abandoned, with one or two exceptions, as the ground has become valuable for villa sites and town lots. There are small quarries at Suffern, near Congers Station, near New City, and west of Haverstraw, at the foot of the Torne mountain. They are worked irregularly and for local supplies of stone. The stone is sometimes known as "Nyack stone," also as "Haverstraw stone."

Glacial Drift

This formation, consisting of unsorted clays, sands, gravels, cobbles and boulders, is found in all parts of the state. The nature of the imbedded stone varies greatly both as to variety and amount. In places the deposits are full of large blocks of stone and of more or less rounded and scratched boulders; in other localities the hard, quartzose cobbles and small boulders predominate. In the sandstone districts of the southern and western parts of the state the surface deposits of glacial drift contain much sandstone, as in the Medina sandstone belt, the Hudson river blue-stone territory and the red sandstones at Haverstraw and Nyack. In the Highlands and in the Adirondacks the rounded, crystalline, granitoid and gneissic rocks predominate. On Long Island the terminal moraine includes a great amount of stone and of many kinds.

The cobblestones were formerly used for paving roadways, but this kind of pavement is no longer laid. From the fact of the stone being picked off the fields in the clearing of land for tillage, the stone of the drift has been known as

*Wm. W. Mather. Geology of the First Geological District, Albany, N. Y., 1843, p. 287.

"field stone;" and they were used in the earlier constructions for walls, foundations and buildings, in localities where no quarries had been opened, and even before resort was had to quarry stone.

Some of the oldest houses on the western end of Long Island, and in the Hudson river counties are built of such field stone. At Yonkers the excavations for foundations and in street grading afford an abundant supply of stone for common wall work. In parts of Brooklyn the drift furnishes a great deal of stone in the shape of huge boulders.

The stone of the drift is generally hard and durable, having been subjected to the wear of rough transportation, and exposed to the weather for ages. The economic use of the surface stone of the drift in constructive work, where they can be laid up in walls, is a desirable utilization of what is still in many parts of the state worse than waste — a nuisance in the tilling of the soil. This formation cannot however be considered as one of the important sources of stone in the quarry industry, although capable of yielding a great deal of rough stone. It will no doubt do so in the further clearing and improvement of the country.

III

DESCRIPTIVE NOTES OF QUARRY DISTRICTS AND QUARRIES

I. Crystalline Rocks

New York, Manhattan Island.— The outcropping ledges of gneissic rocks, from 29th street (on the west side) to the Spuyten Duyvil creek, and from about 16th street northwards, on the eastern side of the island, have been cut through and graded down in so many places that a large amount of stone has been furnished, ready for laying up foundations and for common wall work. These gneisses are generally bluish-gray in color, medium fine-crystalline, highly micaceous and schistose in structure. The beds are thin and tilted at a high angle and in places are in a vertical position. The more micaceous rock is apt to flake and disintegrate on long exposure, especially when the blocks are set on edge. The more feldspathic stone of the granitic veins and dikes and the more hornblendic strata afford a better building material.

The Croton Reservoir, 5th avenue and 42d street and St. Matthew's Lutheran church, Broome street are constructions of the best of the island gneiss.*

The gneissic rocks have been quarried extensively in the 23d and 24th wards, New York city, and in the adjacent southern towns of Westchester county.

The gray variety of quartzite gneiss has been most largely employed for the better class of building. Geologically these gneisses of New York city and the Westchester county quarries are younger than the Laurentian

* For additional examples of the New York island gneiss see tabular statement in Part IV of this report.

rocks of the Highlands of the Hudson and belong to what has been designated the "Manhattan group."*

New York City, Fordham.—A micaceous gneiss is quarried on the property of St. John's College, on the corner of the Boulevard and Pelham avenue. It is of a bluish gray shade of color, and is known locally as "bluestone." The new buildings of the college are constructed of this stone.

Hartsdale, Westchester County.—Gneissic rock is quarried near Hartsdale station on the Harlem railroad for the local market. The county buildings at White Plains are built of this stone.

South-east of White Plains, gneiss is quarried and an example in construction is seen in the M. E. church on the main street.

Scarsdale, Westchester County.—The Seely quarries are a half mile west-north-west of the Scarsdale station, and near the road to Greenville. The stone obtained from this locality consists of feldspar, quartz, hornblende and a little black mica, and these minerals in parallel lines give it a foliated aspect. The exposed ledges near the quarry are firm and solid and show very little alteration due to weathering. This stone has been used in bridge work, for the Bronx river aqueduct, and also in the Williams Bridge reservoir gate-house.

Hastings, Westchester County.—There are three quarries in the vicinity of Hastings. One is owned and worked by the N. Y. C. & H. R. R. R. Co., one mile south of the railroad station. The Munson quarry is three-quarters of a mile east-south-east of the village, and adjoining it on the same ridge is the Ferguson quarry.

The stone of these quarries consists of orthoclase, quartz, hornblende and biotite, arranged generally in parallel lines or thin layers, which gives the rock a gray and striped ap-

---

* Metamorphic Strata of Southeastern New York, by F. J. H. Merrill, Am. Jour. of Science, Vol. xxxix, pp. 389–390.

pearance. The product is shipped to New York city for foundation walls, and is used for common wall work in the adjacent country.

Yonkers, Westchester County.— The Valentine quarry opened on the top of the hill, two miles south-east of Yonkers, and on the Mount Vernon road, is worked at long intervals. The stone is fine-grained, a mixture of feldspar, quartz, and a little hornblende.

Tarrytown, Westchester County.—The old Beekman quarry, one and a quarter miles north of the station, and at the side of the railroad track was worked largely in former years.

Kensico, Westchester County.—A gneissic rock has been quarried extensively on the east side of the Bronx river reservoir, and used in the construction of the reservoir dam.

Union Valley, Putnam County.—The quarries of Jackson & E. Ganung are located four miles from Croton Falls, and in the town of Carmel. The stone has a striped appearance, due to black mica and white feldspar alternating in thin layers. Its main use is for posts and foundations; some of it has been used for monuments and buildings.

Ramapo, Rockland County.—The quarry of Henry L. Pierson is in the hill-side near the N. Y., L. E. & W. R. R., south of the village. The stone is a quartz-syenite, consisting of orthoclase, quartz and hornblende. It is especially suited for heavy masonry on account of its strength and the large size of blocks which can be obtained. Some of this stone has been used for monumental work, and some for the Erie railway bridges.

Suffern, Rockland County.— Granite for cemetery posts and monumental bases has been quarried in a small way from ledges on the road-side west of Suffern station. It is greenish-gray in color, hard to cut and dress, but is durable.

Peekskill, Westchester County.—The granite quarry two miles north-west of Peekskill on the bank of the river is idle.

Iona Island, Rockland County.—There is a large quarry on Iona Island, owned by Daniel E. Donovan, whence stone is obtained for heavy masonry and for macadam material. A large amount is sold annually for road-making. Some of the stone used in the New York and Brooklyn bridge came from this quarry.

West Point, Orange County.—West of the military academy buildings a granitoid gneiss has been quarried at several points for construction of government buildings. The stone occurs in thick beds and the solid, outcropping ledges indicate the durability of the stone, where exposed to the weather. The library building, the old riding academy, and three of the professorial residences and the long lines of retaining walls are constructed of the stone taken from these quarries.

Storm-king Mountain.— The granite quarry at the south-eastern face of Storm-king mountain, near the West Shore railroad track, and a half mile south of Cornwall station, has not been in operation for several years.

Break-neck Mountain Quarry.— Granite has been quarried at several points on the south-west side of this mountain and north of Cold Spring. The quarry sites extend nearly a mile back from the river ; and the work has been to detach blocks of large size, by blasting, and then to break them up into building stones or paving blocks as called for. The Hudson River Broken Stone and Supply Company is now working on the lands of Lewis J. Bailey, producing stone for railroad track ballast.

Mount Adam, Warwick, Orange County.— A granite is quarried at a locality, opened in 1889, on the north end of Mount Adam. It is owned and worked by the Mount Adam Quarry Company, of Middletown.

Little Falls, Herkimer County. — A hornblendic-gneiss rock, known as "blue rock," is quarried at Little Falls for the local market. It was used in the construction of the Erie canal, the N. Y. C. & H. R. R. R., in the R. C. and the Pres. churches, besides several mill and store buildings in the town. The stone has a greenish-gray color, moderately fine-crystalline texture, and is made up of orthoclase, quartz and hornblende. Some of it has a reddish tinge, due to iron stains.

Granite has been quarried in the town of Wilton, two miles north of Saratoga, in the town of Greenfield, and at Wolf Creek, in the town of Hadley. None of these quarries are worked regularly or uninterruptedly.

Adirondack Granite Company, Westport, Essex County.— The granite quarry has been abandoned, on Splitrock mountain near the lake, and three miles from Whallonsburg. Very little stone has been quarried here and little is known of it.

Ausable Granite, Essex County.— The Ausable granite is obtained from quarries on the north and west slopes of Prospect Hill, one and a half miles south of Keeseville. The principal openings are the property of the Ausable Granite Works, whose establishment for dressing the stone is located in Keeseville. This stone is moderately fine-crystalline in texture and is composed of feldspar, hypersthene and biotite. Small grains of pyrite and hematite are occasionally seen in the mass. The stone is hard and expensive to dress but it is susceptible of a high polish and is especially adapted for decorative work and for monuments. The dark, polished surface, with its chatoyant play of colors, contrasts well with the gray, dressed surfaces. The glaciated ledges near the quarries show little alteration due to weathering, and are evidence of the durability of the stone. In some of the weathered surfaces the feldspars

appear changed to kaolin, and the hypersthene is badly decomposed.*

Grindstone Island, Jefferson County.— A red granite is quarried extensively on this island in the St. Lawrence river, north-west of Clayton. There are many outcrops, especially on the western side of the island, and small quarries have been opened at more than twenty different points.

There are three large quarries which are worked extensively and with little interruption. The granite of these quarries is rather coarse-crystalline, red to bright red in color and consists of flesh-colored feldspar, quartz and mica, with very little magnetite as an accessory constituent. Its resemblance to the Scotch granite has given it the name of "International Scotch granite." Examined under the microscope the feldspars show kaolinization. The durability of the stone is witnessed in the unaltered or scarcely altered rock which crops out on the two sides of the quarry. Blocks of large size can be obtained up to the limit in handling and shipping. An examination of a representative specimen of this granite shows that it has a specific gravity of 2.713, equivalent to a weight of 169 pounds per cubic foot. The absorption test indicated 1.55 per cent of water absorbed. The loss in a dilute solution of sulphuric acid was 0.13 per cent. Freezing and thawing produced no apparent change. Exposure to a temperature of 1200 to 1400 degrees F. caused vitrifaction, destruction of color and impaired the strength so that the specimen crumbled

*Tests of the strength of this stone made by Dr. Thos. Egleston, of Columbia College School of Mines, show that it stands 27,000 pounds and breaks at 29,000 pounds to the square inch. Dr. Egleston's series of tests made for the company show further, that when heated to a bright red heat by a blast of a Bunsen burner the stone was not cracked badly; and, at a temperature of 800°-1350° F. and then quenched in cold water the specimens changed in color but otherwise were hardly altered, except at the highest heat. "The outside of the piece was rendered rather crumbly and granular * * * but the piece as a whole was still hard and resists moderate blows of the hammer." [From report made to the Ausable Granite Works.]

with a blow. The greater part of the product of these quarries is in the form of paving blocks and is shipped to western cities, principally Cincinnati and Chicago. The International Granite Company of Montreal uses a large amount for monumental work and building. Examples of this granite can be seen in the large columns of the Senate Chamber of the New Capitol, Albany, and in the Nordheimer building in Montreal.

Limestones and Marbles.

Marbles.

New York City.— A white, crystalline limestone was formerly quarried at Kingsbridge and used in the construction of buildings in the city. The same limestone is now exposed in the deep cut, made for the ship canal at Fort George. Crystalline limestone has been quarried at Morrisania and Mott Haven also, but they can scarcely be called marbles in a proper sense, although used for ordinary construction.

Tremont, New York City.— Four quarries have been opened in the white marble in Tremont, and worked for house trimmings and ordinary construction. The Tremont marble can be seen in the new buildings of St. John's College, Fordham, where it has been used effectively with the dark-blue gneiss. The output of these quarries is small and unimportant.

Tuckahoe, Westchester County.— The Tuckahoe Marble Company and the New York Marble Company quarry marble at Tuckahoe. The first named company works what was formerly known as the Young's quarry. The latter company has a large quarry adjoining it on the north. The stone of these quarries is coarsely-crystalline in texture and pure white. In composition it is a true dolomite. A sample from the New York Quarry Company (J. M.

Masterton) was found to contain 30.63 per cent of lime, and 20.77 per cent of magnesia, and 0.91 per cent of insoluble matter. The specific gravity was 2.868, equivalent to 178 pounds per cubic foot. The absorption test indicated 0.14 per cent of water absorbed. The loss in weight when acted upon by sulphuric acid gas amounted to 0.25 per cent. Freezing and thawing produced no apparent change. At a high temperature the specimen was calcined and crumbled at the touch. The Tuckahoe quarries have been worked since 1820, and have produced a large aggregate of marble, which has been put in large and expensive buildings in cities along the Atlantic coast from Boston to New Orleans. It is comparatively durable and resists the action of the weather better than much of the Vermont and the foreign marbles, which have been used in New York city. A noticeable change from long exposure is a slight yellowish shade of color, which can be seen in the U. S. Assay Office building, Wall street, in the building of the National Shoe and Leather Bank, and in the houses of the cardinal and archbishop on Madison avenue. Some of the more prominent structures in which Tuckahoe marble has been used are the following: The U. S. Post-office, U. S. Naval Observatory and the Soldiers' Home, Washington, D. C.; the City Hall, Brooklyn; the Stewart buildings on Broadway and Fifth avenue, New York; and the Sears building, Vendome Hotel and Revere Bank in Boston.*

Pleasantville, Westchester County.—The Snowflake Marble Company's quarry is one mile south-east of the village of Pleasantville. This marble is white and very coarse-crystalline. It is much harder than the Vermont marbles and does not compete with them for monumental work. The chemical analysis shows it to be a dolomitic limestone or marble. Examples of its use are: St. Patrick's R. C. Cathedral, Fifth avenue, and the Union Dime Savings building,

* For other examples of Tuckahoe marble see tabular statement in this report of stone used in New York city.

Sixth avenue and Thirty-second street, New York city; also the M. E. church in Sing Sing.

Hastings, Westchester County.— The marble quarries near Hastings produce a white, fine-crystalline, dolomitic stone. They have been idle for many years.

Sing Sing, Westchester County.—The crystalline limestone east of the state prison and on the state property was formerly worked for marble; and the prison buildings, and the State Hall at Albany are built of stone which came from these quarries.

White limestone in the Dover Plains—Patterson valley, has been opened at several points between Patterson on the south and Dover Plains on the north, and a white marble has been obtained and worked up largely for monumental bases and grave-stones. The stone of these quarries is bluish-white and fine-crystalline in texture and is readily dressed. They have been idle for several years past.

Towner's Four Corners, Putnam County.— The old quarry at this locality was opened two years ago for stone to be used in the construction of the Sodom dam. The stone is gray and white, rather coarse-crystalline and contains many crystals of white pyroxene scattered through the mass. The friable and decomposed condition of the ledges near the quarry leads to the belief that the stone is not very durable.

Gouverneur, St. Lawrence County.— At Gouverneur there are three companies working marble quarries. The works and quarries are located about one mile south-west of the village and near the R., W. & O. R. R. line. There are two leading varieties of stone obtained in these quarries; a light gray, at the top, and a dark blue, at the bottom. The latter resembles, when dressed, some of the gray granites. Both varieties are coarse-crystalline in structure. A specimen from the St. Lawrence Marble Company's quarry was found to have a specific gravity of 2.756, equivalent to

a weight of 171 pounds per cubic foot; 51.57 per cent of lime, 3.29 per cent of magnesia and 1.29 per cent insoluble matter. The absorbed water amounted to 1.16 per cent. The loss, when acted upon by sulphurous acid gas, was 0.15 per cent; freezing and thawing produced no apparent change. At a high temperature, 1200 to 1400 degrees the specimen was fully calcined.

"The Gouverneur marble was employed at least fifty years ago for grave-stones, and in the Riverside cemetery, at Gouverneur, these old grave-stones, bearing dates from 1818 onward, can now be seen. As compared with the white marble head-stones from Vermont it is more durable; and there is not so luxuriant a growth of moss and lichen as on the latter stone, but in the case of the older Gouverneur stone some signs of decay and disintegration, particularly on the tops, are noticeable, and small pieces can be chipped off with the knife blade. The durability of the stone for building purposes has been tested in some of the older structures in Gouverneur."

The leading use of the Gouverneur marble is for monuments. A large amount is sold for rock-ashlar, for buildings, principally to western markets. It may be seen in several business blocks in Gouverneur; Hubbard house, Malone; in the Presbyterian church, Canton; in the Flower Memorial chapel, Watertown; and the State Asylum for the Insane at Ogdensburg and Merrick block, Syracuse.

Canton, St. Lawrence County.—A grayish-white marble is opened in this town, four miles easterly from Canton. It has not been worked lately.

Verd-Antique Marble

Thurman, Warren County.— The verd-antique marble locality is opened in this town, eight miles north-west of Thurman, and five miles from Glendale station. The quarry was worked for three years and then abandoned. The stone

is of a yellowish-green color and not the deep-rich green, characteristic of precious serpentine.

Bolton, Warren County.—Localities of serpentine marble are known in this town, but they have not been developed into quarries.

Port Henry, Essex County.— The Burlington Manufacturing Company has a quarry of verd-antique marble about one-quarter of a mile north of the Cheever ore bed. The stone is coarse-granular, green and white, speckled, in color and is capable of taking a good polish. The place has been idle since 1886.

Limestones

Warwick, Orange County.—The blue, magnesian limestone formation here affords a good building stone for the local supply, and the quarries are worked at intervals, according to the demand.

Mapes Corner, Orange County.—The quarries on Mt. Lookout near Orange Farm station of the Pine Island Branch railroad furnish stone to Goshen, Chester and the adjacent country. The stone occurs in thick beds and is adapted for massive wall work. The Presbyterian, Methodist Episcopal and Roman Catholic churches in Goshen and the Roman Catholic church in Chester are examples in construction.

Newburgh.— Blue limestone is quarried south-west of the city, near the old Cochecton turnpike, and on the north slope of Snake Hill. It has been used largely for retaining walls and foundations in the city. St. George's Protestant Episcopal church is built of stone from this range. North of the city there is a small quarry on the river road.

New Hamburgh, Dutchess County.— The quarry, two miles north of New Hamburgh, is worked for bridge stone for the N. Y. C. & H. R. R. R. Company and for ballast.

Kingston, Ulster County.— The outcrops of the Onondaga limestone formation in the city have afforded stone for

building from the earliest settlement of the place, and the old stone houses are in part built of this stone. Quarries have been opened from the Kingston and Rondout railroad on Main street, and near Union avenue south-west to the cemetery, and near Washington and Pearl streets in the western part of the city. The beds are from two to eight feet thick. Two well-marked systems of vertical joints divide the rock into blocks of a size convenient for quarrying. Freshly fractured surfaces of this limestone are of a dark-blue shade ; weathered surfaces are gray, in some cases brown-yellow. Thin seams of argillaceous or more clayey rock, from one-sixteenth to one-fourth of an inch, alternating irregularly with the calcareous portions, cause unequal wear in exposed faces and develop lines of dirty yellow in the gray background of the stone, which are unsightly. They do not, however, impair seriously its strength or durability, except when the stone is set on edge. Some chert and scattering crystal of pyrite occur in some of the surface beds, but the lower and thicker beds appear to be free from these minerals. The stone is best adapted for foundations and for heavy masonry as it is hard, dense, very strong and to be had in large blocks. These quarries have furnished the great bulk of stone used in Kingston. The piers of the Poughkeepsie bridge, part of the anchorages and piers of the New York and Brooklyn bridge ; locks at Cohoes and Waterford, St. Patrick's Roman Catholic church in Newburgh are examples of the Kingston limestones. These quarries are not worked continuously.

Greenport, Columbia County.—The quarries near Hudson in the town of Greenport are opened on the north end, and in the western escarpment of Becraft's mountain. Geologically they are in the Upper Tentamerus and Encrical limestone divisions of the Lower Helderberg horizon and the stone is a nearly pure carbonate of lime. It is gray to reddish-gray in color, sub-crystalline to crystalline and highly fossiliferous. The beds are from four inches to six feet

thick, and afford blocks of large size. The stone is susceptible of a high polish, and is adapted to decorative purposes, preferable for interior work. It has been known as "coral-shell marble" and "scutella marble." Nearly all of the foundations and retaining walls in the city of Hudson are of this stone. The Presbyterian church is a good architectural example of its use. The quarries of F. W. Jones are worked continuously and the railroad connects them with the N. Y. C. & H. R. R. R. and the river.

Champlain Valley

Saratoga Springs, Saratoga County.— Blue limestone for common masonry has been quarried at several places in the town.

The largest quarries are those of Charles Slade, Isaac Wager, and Prince Wing and about three miles west. The geological horizon is Calciferous and Trenton.

The stone is of a dark blue shade. That of the thick beds is rather easily dressed and is worked up into dimension blocks for curbing and house-trimming, and heavy bridge work on the Del. & Hudson Canal Co.'s railroad lines. It has to be carted to Saratoga, where a large part of the total output is used in house-work.

Sandy Hill, Warren County.— The Sandy Hill Quarry Company has extensive quarries two miles from the Sandy Hill railroad station, and a half mile north-east of the canal.

The formation is that of the calciferous sand rock. A large area has been worked over to a slight depth. There is a thin covering of earth from one to two feet thick; then quarry beds one to seven feet thick, down at least to forty feet. The dip is less than 5° to the south.

Open and vertical, dirt-filled joints are a peculiar feature and facilitate the removal of huge blocks. The long working face and natural drainage are also advantages. And with a complete equipment of steam drills, derricks and movable railways, the capacity of production is large. The annual

output in cubic yards is greater than that of any other single building-stone quarry in the state, and is increasing from year to year.

The stone is of a light blue color, and fine-grained. Its specific gravity is 2.764 and its weight per cubic foot 172 pounds. A partial chemical analysis gave 27.35 per cent of matter insoluble in dilute hydrochloric acid. The lime and magnesia are present in proportions approximating to a dolomite. The absorption capacity was found to be 0.14 per cent. When treated with a one per-cent solution of sulphuric acid the loss in weight was 2.51 per-cent. Freezing and thawing did not produce any apparent effect. Exposed to a heat of 1200° to 1400° F. the stone was partially calcined and crumbled with a blow. On account of its hardness, it cannot be dressed economically, and very little of it is used for house-work. It is specially adapted to heavy masonry. It was used in the Arthur Kill bridge on Staten Island Sound, in the rear wall on Governor's Island, in the walls of the sunken track of the Harlem railroad, in the Croton aqueduct gate-house, New York city, in the Poughkeepsie bridge piers, and in the battle monument at Bennington, Vermont.

Glens Falls. — There are two large quarries in the Trenton limestone, one on each side of the Hudson river at Glens Falls. That of the Morgan Lumber and Lime Company on the Saratoga county side is no longer worked for building stone. The quarry on the left bank, in Warren county, belongs to the Glens Falls Company, and is worked for black limestone or "marble."

There is a long working-face in which a gray, crystalline limestone is seen in thin beds at the top, then the black marble, which has, in two beds, a total thickness of twelve feet.

The gray limestone is sold in the rough for common wall-work, or cut into house-trimmimg material.

The black marble is fine-grained and compact, hard and brittle, but can be dressed in any style. It takes a brilliant

polish and is jet black. Its specific gravity is 2.718 and its weight per cubic foot 169.4 pounds. According to analysis it is a magnesian limestone, carrying a high percentage (30.18) of matters insoluble in hydrochloric acid. The percentage of water absorbed is relatively low, 0.08. The specimens remained unchanged in the tests by alternate freezing and thawing. At a high heat (1200°–1400°) the stone was calcined and crumbled to the touch.

For tiling it is particularly well adapted, as it does not wear slippery. It is worked up at a mill at the quarry, and tiles, shelves, mantels, lintels, coping-stones, wainscoting, billiard-table tops and material for all inside, decorative work are cut. Among the examples of inside work, the building of the Equitable Assurance Company, Broadway, New York, is perhaps the best. The market for it is all over the country.

The quarry is at the side of the Champlain canal (feeder) and one-half mile from the Delaware and Hudson Canal Company's railroad.

Whitehall, Washington County. — The quarry of the Arana Marble Company at the side of the railroad, about half way between Whitehall and Fair Haven, has not been worked except for stone for flux to iron furnaces.

Crown Point, Essex County.—The quarries in this town have not been worked recently.

Willsborough Neck, Essex County.—The Chazy limestone underlying at a slight depth the surface on this Neck, has been opened in two large quarries. A large business was done in 1854 and onward for about twenty years, and much of the stone was used in the foundations of the capitol at Albany, and in those of the New York and Brooklyn bridge.

The stone can be seen in the Reformed church, Swan street, Albany, and in the State Street M. E. church in Troy. It has been known in the market as "Lake Champlain bluestone." The stone is light-blue in color, weathering to a light-gray.

The light stripping necessary to open the quarries, the uniform thickness of the beds, the regular, vertical joints, and the location on the lake accessible by boats, are notable advantages. One quarry only is now worked and that in a small way.

Plattsburgh, Clinton County.—In the vicinity of Plattsburgh there are several small quarries in the Chazy limestone which furnish stone for construction in the town. The St. John's Roman Catholic church and the First Presbyterian church are built of this stone.

South of Plattsburgh three and a half miles, the Burlington Manufacturing Company has a quarry where a limestone is obtained, which is known in the market as "Lepanto marble." It is fine-crystalline in texture, gray to red in color and takes a high polish. The specific gravity is 2.709, and its weight per cubic foot is 168.8 pounds. It contains 1.54 per cent only of matter insoluble in dilute hydrochloric acid and 94.87 per cent of calcium carbonate. The absorption test showed 0.145 per cent of water absorbed. In freezing and thawing there was no change, but at a high heat the stone was fully calcined and crumbled to the touch.

The stone has to be hauled by teams to the lake, one mile east of the quarry. It is dressed at the company's works in Burlington, Vermont.

The principal markets for it are Burlington and Plattsburgh.

Mohawk Valley

In Schenectady county there are two small quarries on the south side of the Mohawk river, and near **Pattersonville** station, which are worked at infrequent intervals, for the local market. They are in the horizon of the Trenton limestone.

Amsterdam, Montgomery County.— The Birdseye limestone and the Trenton limestone outcrops in the valley of the Chuctanunda creek afford sites for quarrying building stone, and four quarries have been opened north of the

town of Amsterdam, and at a height of 180 to 250 feet above the Mohawk valley. The stone is in beds from six inches to three feet thick which lie almost horizontally. The rough stone is sold for making lime, the best is cut into platforms, sills, lintels, and house-trimming materials. The principal markets are Amsterdam, Albany, Cohoes and Troy. Shanahan's quarry furnished a large amount of stone for the foundation of the Capitol at Albany. The other quarries are Hewitt's and Vanderveer's.

Tribes Hill, Montgomery County.— There are two large quarries near the station of the N. Y. C. & H. R. R. R. at Tribes Hill: that of Henry Hurst & Son, a few rods west of the depot, and one east of it, belonging to James Shanahan. The former is worked steadily and mainly for construction in the neighboring towns; the latter has been idle for several years.

The upper strata in both quarries are of blue limestone suitable for common rubble work or for lime-making. The gray stone of the thicker and lower beds is fine-crystalline to sub-crystalline in texture, and having a specific gravity of 2.718. The computed weight per cubic foot is 169 pounds. It contains, according to analysis, matters insoluble in dilute hydrochloric acid 2.48 per cent, and of lime 53.57 per cent or equivalent 95.68 per cent of calcium carbonate. The absorption percentage was found to be 0.14. Freezing and thawing produced no change. At a red heat it was reduced to lime.

The markets for Tribes Hill limestone are Albany, Troy, Cohoes, Stillwater, Mechanicsville, Hoosick Falls, Johnstown and Gloversville.

The Edison House, Schenectady, is an example in construction.

Fine-tooled surfaces are of a light-gray shade of color; polished, it looks almost like a black marble.*

* There is a fine cubical block from Mr. Shanahan's quarry in the State Museum collection whose polished face is almost jet black.

Quarries have been opened at many points in the valley of the Mohawk between Amsterdam and Little Falls, and in the Trenton and Birdseye limestone formations. Some of them have been idle for many years; others have furnished small quantities of stone for home use, and hence are only of local importance.

Canajoharie, Montgomery County.— There are three building-stone quarries opened in and near Canajoharie, and in the Calciferous formation, two of which are worked continuously. The openings are large, and there is much variation in the beds. The leading varieties are a blue stone and a gray, sub-crystalline stone, the latter of which is cut for monumental bases, sewer blocks, house trimmings and canal lock construction. A specimen of the gray variety from the quarry of A. C. & C. H. Shaper was examined and gave an analysis 46.92 per cent of lime, equivalent to 83.92 per cent of calcium carbonate and 10.06 per cent of insoluble matters. The specific gravity was 2.726 and the weight 169.9 pounds per cubic foot. Its absorptive capacity was found to be 0.07 per cent. The alternate freezing and thawing produced no change, but the high temperature calcined the specimen so that it fell to pieces in handling. The stone of these quarries can be seen in the churches of Canajoharie and Fort Plain, and in some of the large mill buildings of Utica.

Palatine Bridge, Montgomery County.— On the north or left bank of the Mohawk there are two large quarries which furnish blue and gray limestones for common wall work and for cut work. These quarries are in the same formation as those across the river in Canajoharie, and the stone resembles closely that of the latter quarries. In all of them the beds are dipping at 5° to 10° southerly, and the stripping is comparatively light.

At Fort Plain and St. Johnsville, Montgomery County, the Birdseye limestone is opened in small quarries for local use.

Little Falls, Herkimer County.—There are three quarries in the calciferous sandrock, in the bluff north of the town, which produce stone for common wall work for local use. The stone is fine-grained and of a bluish-gray shade of color, weathering to gray. North-west of the town one and a half miles, there is a quarry on the Wilcox property and in the Trenton and Birdseye limestone. The stone is sold for curbing and flagging mainly.

Newport, Herkimer County.— In this town there are three quarries in the limestone, which furnish stone for local use, and for canal lock construction.

Holland Patent, Oneida County. — The quarries in the Trenton limestone at this place are of local importance only.

Prospect, Oneida County.— The cañon of the West Canada creek has exposed the Trenton limestone between this place and Trenton Falls, and made the upper beds easily accessible, and workable to advantage.

On the west side of the creek (Oneida county) Evan S. Thomas and H. & L. W. Jones have quarries ; on the east side, in Herkimer county, there are two quarries, worked by Edward Callahan and George & Griffith of Utica. The covering of soil and earth is light, and is thrown into the gorge with waste rock. The beds lie nearly horizontal and are thin so as to be cut to advantage for platforms, flagging-stone, lintels, sills and water-tables. The stone is carted to Prospect station, one and a half miles, and there shipped.

A representative specimen of the best stone from the quarry of Evan S. Thomas was found to have a specific gravity of 2.725 and a weight per cubic foot of 169.8 pounds. The percentage of lime 53.10 found, indicates 94.82 per cent of calcium carbonate. The absorption percentage is 0.14. The freezing and thawing tests produced no apparent change; heating to 1200°–1400° F., and cooling suddenly made it a crumbling mass of lime.

The stone of these quarries is known as "Trenton gray limestone." It has been employed extensively in Utica,

Rome, Norwich and other places, Examples of it are in the U. S. Government building, in St. John's Roman Catholic and in St. Paul's Lutheran churches in Utica ; in the Roman Catholic churches at Little Falls and at Sandy Hill ; and in the Methodist Epistopal church in Herkimer. Some of the stone is cut at Utica into monumental bases. The best cut-stone is gray in color and sub-crystalline in texture.

It fades after long exposure to the atmosphere and loses its freshness of surface.

Leyden, Lewis County.— Blue limestone has been quarried near Talcottville, on Sugar river at Leyden station, and near Port Leyden. Much stone for canal lock construction has been obtained at some of the Leyden quarries.

Lowville, Lewis County.— L. H. Carter and Hiram Gowdy have quarries south-east of the village, and east of the R., W. & O. R. R. line. The geological horizon is the Trenton and Birdseye limestones. The beds are nearly horizontal, and some of them are two and three feet thick. The heavy beds furnish stone for bridge abutments.

The Lowville stone is generally much darker in shade than the Prospect stone and looks well when fine-tooled. The principal market is Lowville and adjoining towns. Much of the stone has been used on the U. & B. R. branch in bridge abutments.

Watertown, Jefferson County.—The gray of the Trenton and the heavy beds of the Black river limestones are finely exposed to view in the gorge of the Black river at Watertown. They are not worked.

Three Mile Bay, Jefferson County.— At this place the limestone is so thinly covered as to be readily opened, and stone for local use is obtained in several small quarries. Barrow's quarry is close to the lake shore, and half a mile from the railroad station.

The lower beds are worked into cut stone for house trimming and cemetery work. Watertown and the lake ports are the chief markets.

At **Brownsville** some limestone is got at the side of the Cape Vincent branch railroad for local use.

Chaumont, Jefferson County.— There are several large quarries at Chaumont, two of which, Adams Bros.' and Du Fort & Son, are run steadily. The former has a quarry face a mile in length. They are in the horizon of the Black river and Trenton limestones. The beds dip westward at a small angle and are divided into large blocks by vertical joints.

There is a blue limestone at the top which is made into lime, or used for common wall work. Under it is the gray sub-crystalline variety, in what are known as the 32-inch and the 16-inch beds, beside thinner beds lower down. The surface courses furnish stone for lime manufacture. The stone of the thicker beds is cut for lock facing and bridge work; the thin beds are worked into house trimmings. These quarries are on the shore of the bay, convenient to navigation, and are near the railroad also. The product is increasing from year to year. Much of the Chaumont stone has been put into Erie canal locks.

The Protestant Episcopal church, the County Clerk's office and City Opera House in Watertown are examples in construction.

Oswego, Fulton and Utica are other markets.

Ogdensburg, St. Lawrence County.— The number of stone buildings in Ogdensburg is comparatively large, and the material is almost all out of local quarries in the Chazy limestone formation.

The Town Hall and the St. John's Protestant Episcopal church are beautiful examples of the stone which is found here. The quarry which is now worked for the local supply is on the Oswegatchie river, two miles south of the town.

Norwood, St. Lawrence County.—A blue limestone is quarried one and a half miles from Norwood on the O. & L. C. R. R. line. It can be seen in the Presbyterian churches at

Malone, Waddington and Canton; the Roman Catholic church at Hogansburg, and in the county buildings at Canton.

Schoharie, Schoharie County.— Limestones of the Lower Helderberg and Water-lime groups crop out in the valley east of the village of Schoharie, and afford excellent building stone. The black, tentaculite limestone is very compact and takes a high polish. The use thus far is for the town only.

The Reformed Dutch church and Revolutionary stone fort in the lower Schoharie valley, built in 1766, shows how well the limestone resists the weather.

Howe's Cave, Schoharie County. — Formerly a large amount of building stone was quarried here in the bluff, above the hydraulic limestone beds. The latter only are now worked.

Cobleskill, Schoharie County.— William Reilly has two quarries near this place; one a half mile north-west of the village, and the other about two miles to the north-east. Both are in the Upper Helderberg limestone.

Two principal kinds of stone are taken out,— a hard bluestone, and a gray, sub-crystalline variety, which is cut and dressed for dimension work. A specimen of the latter was examined and found to contain 53.86 per cent of lime, or 96.18 per cent of carbonate of lime, and 2.26 per cent of matter insoluble in dilute hydrochloric acid. Its specific gravity was 2.713, equivalent to a weight of 169 pounds to the cubic foot. The absorption percentage was 0.109. Unaffected apparently by alternate freezing and thawing, it was calcined at a high heat (1200°–1400° F.).

The stone of this quarry has a home market; it is shipped to Binghamton, Oneonta, Cooperstown, Albany and other places on the Albany and Susquehanna railroad. It was used in the German Methodist Episcopal church, Clinton and Alexander streets; in the Roman Catholic church, Central avenue, and in the Hawk street viaduct, Albany.

Sharon Springs, Schoharie County.— The Lower Helderberg limestones at Sharon Springs and its vicinity are opened at several points, and stone is obtained for local use in flagging, cross-walks and house work. The limestones of the Upper Helderberg epoch in their westward extension into Otsego county, crop out in many ledges in the towns of **Cherry Valley** and **Springfield,** and afford good building stone for local use. The Presbyterian church and Belcher House, in the village of Cherry Valley; the Otsego county jail, Fenimore House, and the house of Edward Clark in Cooperstown, are examples in construction of the stone from these quarries. In the town of **Stark,** in **Herkimer** county, a small quarry has been worked in the same gray limestone.

The corniferous limestone was opened many years ago in small quarries at **Cassville, Waterville** and **Oriskany Falls,** in the southern part of Oneida county.

Perryville, Madison County.— Three quarries are worked at irregular times at this place. The stone is the Onondaga gray limestone and is used as there is a demand for it; for bridge work mainly.

In Onondaga county the Onondaga gray limestone is well developed and is quarried extensively. There are quarries at **Manlius, Jamesville,** on the **Onondaga Indian Reservation,** and at **Splitrock.**

Onondaga Indian Reservation Quarries.— This group of quarries is six and a half miles south of Syracuse and in the north-east corner of the Reservation. There are five parties at work within a range of three-eighths of a mile from north to south. The dip of the beds is generally to the west-south-west, and at low angles.

The upper beds are blue limestone which is waste, excepting a small part which is used for rubble. The gray limestone has a crystalline texture, and a specific gravity of 2.708, equivalent to a weight of 168 pounds per cubic foot. It is dressed readily and fine-tooled surfaces are light gray,

resembling the gray granites of Maine, and contrasting well with the rock-face stone which is so much darker-colored. It is a strong and durable stone, as is proven in the old buildings in Syracuse and elsewhere. Specimens of fine-cut gray limestone, which have been exposed to the weather forty-eight years in the old city hall, exhibit no indications of decay, and no alteration other than a fading in color. One defect in the stone is the very thin, black, shaly seams which sometimes give it the appearance of checking; but there are no clay seams as in some of our limestones.

In quarrying it is not possible to get as thick beds as in the granites and some of the sandstones, two feet being the average thickness.

A representative specimen from Hughes Bros., of Syracuse, was found to contain 53.76 per cent of lime and 0.60 per cent of magnesia, or 96 per cent of carbonate of lime and 1.26 per cent of carbonate of magnesia. Matters insoluble in dilute acid were 1.52 per cent. The water absorbed was 0.14 per cent. The freezing and thawing tests did not produce any apparent change. Subjected to a temperature of 1200°–1400° F. the stone was fully calcined.

Split Rock Quarries.— This group is in the town of Onondaga, five to seven miles west of Syracuse, and in the north-facing escarpment of the Upper Helderberg rocks. The beds are thinly covered by earth, and one or two beds, at most are worked. In this way a large area has been quarried over. A great deal of stone for the Erie canal construction was obtained from these quarries.*

The Onondaga gray limestone has been the principal building stone in Syracuse. Among the many fine structures, in which it has been used for walls and trimmings, may be noted the following: United States Government building; new city hall; hall of languages, Syracuse university; Onondaga County Savings bank; St. Paul's Prot-

*One of the first railroads in Central New York was constructed from the Split Rock quarries to the canal, one mile west of Syracuse.— H. W. Clarke.

estant Episcopal church; St. Mary's Roman Catholic church, and the May Memorial church.

Oswego, Binghamton, Elmira, and other cities and towns in the central part of the State, are markets for the stone.

Union Springs, Cayuga County.— The Onondaga limestone is opened in a group of quarries at Hamburg, one mile south of Union Springs, and on Daniel Mosher's farm, east of the village. A remarkable feature is the persistence of the quarry beds and their uniformity in the several quarries. The glacial drift on the limestone is from one to ten feet thick; the upper beds (or tiers, as here known) are blue limestone, and from two to twenty-four inches thick; the lower beds are generally thick and of a gray, sub-crystalline stone. The thin beds answer for flagging; the heavier beds are worked into dimension blocks for building, canal-lock and bridge-pier construction. The markets are reached by boats on line of Erie canal.

The **Hamburg** quarries were opened more than sixty years ago, and the old grist-mill, the Chase house and the Howland house, show how well the stone has stood for that length of time.

Auburn, Cayuga County.— The Upper Helderberg limestone ledges at Auburn, have afforded a good building stone; and a comparatively large percentage of stone buildings in that city are evidence of its enduring property. The Garrett Stone and Coal Company, L. S. Goodrich & Son, and John Bennett & Son, have quarries here. The first-named was opened in 1810. The blue limestone of the upper beds is used for rubble-work, only. The gray limestone occurring in "tiers" of from six inches to two feet thick, is cut for house trimmings, platforms, curbing and gutter-stones. It is dressed readily, and is of a light gray color when fine cut; the rock face is dark-colored.

It has been used in six beautiful churches; in the city hall; in the Auburn Theological Seminary buildings; in

the State arsenal and State prison, besides many stores and other structures in the city.

The principal outside markets have been Sayre, Pa., Owego, Elmira, Oswego, Geneva, Canandaigua, Newark Valley and Palmyra.

The Corniferous or Upper Helderberg group of lime-stone, including as the upper part the Corniferous or Seneca limestone, is well represented in a belt crossing the towns of **Seneca Falls** and **Waterloo,** and quarries are opened in both towns, for local use mainly.

The Waterloo quarries are large, and kept in operation almost all of the year. That of Loren Thomas, a half mile south of the town has been worked for more than sixty years. Remarkably regular systems of vertical joints, at uniform distances apart, divide the stone into large, rectangular blocks, and facilitate the quarrying.

The beds are from seven to twenty-six inches thick, and fourteen to sixteen in number. The stone of these quarries resembles that of the formation to the east, in Cayuga and Onondaga counties.

The same geological formation appears in Ontario county. and there are small quarries in the towns of **Canandaigua** and **Victor,** which do a local business.

Going west the outcrops of the rocks of this geological epoch have been opened in small quarries in **Mendon, Monroe County**; near **Caledonia** in **Livingston County**; and in **Leroy, Genesee County.** There are two quarries at the latter place. They produce stone for common wall work. Some of the limestone found north of the town is said to dress well, and to be capable of receiving a good polish.

Williamsville, Erie County.—Several quarries have been opened at Williamsville, ten miles north-east of Buffalo. J. S. & F. H. Youngs, and D. & H. Fogelsonger, work quarries for building stone, mainly, for the Buffalo market. They are small, and not deep, as the rock is near the surface. The stone is light-gray, fine-crystalline, and dresses well.

It has a specific gravity of 2.708 and weighs 168 pounds per cubic foot. It contains 93.44 per cent of calcium carbonate, and 3.82 per cent of insoluble matter in dilute hydrochloric acid. Its absorption percentage is 0.16. It resisted freezing and thawing tests without apparent change, but was calcined at a temperature of 1200°–1400° F. It is used in Buffalo for cut-stone trimmings. The quarries are six miles from the New York Central railroad line, but nearly all the stone is carted by teams to Buffalo.

Buffalo.— The Corniferous limestone and the Onondaga limestone are quarried extensively in this city for all common wall work.

The Buffalo Cement Company's quarry is the northernmost. South of it is the Yamarthal group of quarries. The drift-earth is thin, covering the quarry beds to a depth of one to four feet, as opened thus far. The limestone is in courses, lying horizontal, and from nine inches to two and a half feet thick. The stone is dark-colored, hard, compact and strong, and is well liked for walls and foundations. It is delivered in wagon loads, in the city, at $6 per cord.

Black Rock, Erie County.— The Corniferous limestone at this place was formerly quarried for canal construction.

Niagara Limestone

Rochester.— Nearly all of the common building stone used in Rochester, is obtained from quarries in the northeastern and in the western quarters of the city. A very small part of the best gray stone is used for rock-face ashlar work. The business is entirely limited to the city.

Lockport, Niagara County.— The Whitmore and Carpenter quarries are on the Erie canal, in the south-western part of the town. The upper layers of stone are thin, but are succeeded by thick beds, to a depth of twelve to twenty-four feet. The dip is southward at a low angle. The stone is known as the Lockport gray limestone. It is light-gray, in

places variegated with red; dense, solid, and made up of comminuted crinoidal stems and coralline masses. The fine-cut surface does not differ greatly in shade of color from that of the rock-face stone. These quarries were opened when the Erie canal was dug, in 1825, and the Carpenters began work here in 1829. The production has diminished greatly, owing to the general use of sandstones.

It has been used in Lockport for common wall work; for house trimmings and monumental uses it has had a wide market. The various buildings in the town show how well it has withstood the action of the weather for years.

The Lenox Library building, Fifth avenue and Seventieth to Seventy-first streets, New York, is an example of its use, but one in which the stone shows crevices and holes, due to unequal weathering of coralline masses and the more fossiliferous portion. The improper position of the stone in the walls (more than forty per cent being set on edge) may explain the serious defects seen in this example.*

West of Lockport the Niagara limestone is quarried at **Niagara Falls,** for building in the town. Across the river, on the Canadian side, the same formation near Queenstown, furnishes some stone to Buffalo which is in much favor with some architects and builders.

II. Fragmental Rocks

Sandstones

Fort Ann, Washington County.— A gray sandstone is quarried two miles north of the village, and at the side of the canal. It is used in Whitehall.

Whitehall, Washington County.— The cliffs of Potsdam sandstone, east of the town, yield stone for local use. The stone is hard and strong, and is valuable for foundations,

* See 10th Census of United States, Vol. x, page 369, *Durability of building stones in New York city and vicinity, by Alexis A. Julien.*

retaining-walls, and where it can be used without much cutting or dressing.

Port Henry, Essex County.— The outcrops of the Potsdam sandstone in the town and west of it afford quarrying sites. The quarry of L. W. Bond is worked for the local market, and the towns on the line of Delaware and Hudson Canal Company's railroad in the Champlain valley. The stone is hard, of a gray shade, excepting the surface beds, which are weathered to a rusty-red color. It is nearly all silica, and is capable of resisting the ordinary atmospheric agents for years, when the blocks are laid on their bedding planes. A serious drawback to its more extensive use is the cost of cutting and dressing.

Examples of this stone in construction are seen in the Presbyterian church, and in the Sherman Library building, and the railroad depot in the town.*

Keeseville.— The Ausable river, the boundary line of Essex and Clinton counties, has at this place, and at the famous chasm below the village, worn its bed down deeply into the sandstone, and along its banks quarries have been opened in both counties for local supply.

The thin beds make a fairly good flagging-stone. The heavier beds yield good stone for ordinary wall work; and a great amount of it has been put into buildings in Keeseville. In color it is gray-white. It is rather more granular and not as hard as the Port Henry sandstone.

Malone, Franklin County.— The sandstone of the Potsdam horizon is opened by small quarries at this point, and at localities to the west, but they are unimportant, and the next group to be noted is at

Potsdam, St. Lawrence County.— The formation is so well developed in the valley of the Raquette river, south-east of the village of Potsdam, that it has been named the Potsdam sandstone.

---

* This quarry yielded the trails of trilobites upon ripple-marked beds, fine specimens of which are in the State Museum, and the American Museum, New York. (See Forty-second Annual Report, New York State Museum, pp. 25–29.)

Mrs. Charles Cox, Thomas S. Clarkson and the Potsdam Red Sandstone Company have quarries along the river, at an average distance of three miles, east-south-east of the village. The beds range in thickness from a few inches to six feet, and afford blocks of varying sizes. In most of the beds there is a more or less laminated structure, especially in the darker-red colored stone.

The color is light-pink, light-red or salmon colored, and red to reddish-brown, varying in the several openings.

A representative specimen, taken from the company's quarry, has a specific gravity of 2.604, equivalent to a weight of 162 pounds to the cubic foot. Its percentage of silica is relatively large, and the cementing material appears to be siliceous also. The oxide of iron, as determined by analysis is 0.36 (ferrous oxide) in amount.

In the absorption test 2.08 per cent of water was absorbed by the dry stone. There was no loss of weight in repeated treatment with water containing carbonic acid gas and with sulphurous acid gas. A solution of 1 per cent of sulphuric acid occasioned a slight loss in weight, equivalent to 0.02 per cent. The test of freezing and thawing left the stone apparently unchanged. When heated to 1200°–1400° F. and suddenly cooled, the color was unaltered, there were no checks, and the strength of the specimen was but little impaired.

Potsdam sandstone has been tested severely in its home. The wide range of temperature between the maxima of summer and the minima of winter, and the large annual precipitation, of which a considerable part is in the form of snow, present the conditions which demand material with resisting capacity. The houses of Gen. Merritt and Senator Erwin, and other buildings, erected about sixty years ago, are solid structures to-day. The arris and corners are as sharp as when first cut, and the faces show no sign of scaling or flaking. The pavements also show how well the stone wears under use, not becoming smooth and slippery

when wet. The Normal school buildings, the town hall, the Cox block, and the Presbyterian, Universalist and Episcopal churches are the more prominent structures of this stone in Potsdam. In the last-named church there is much carved work, making it very expensive on account of the hardness of the stone.

The Potsdam stone finds a wide market, and the demand for it is growing, as its beauty, strength and durability are better known and appreciated.

On account of its hardness, and the cost of fine-tool dressing, the stone is best adapted to rock-face, ashlar work. It may be seen in the "Florence," South Salina street, Syracuse; All Saints' cathedral, Albany; Columbia college and Rutger's Protestant Episcopal church, Seventy-second street, New York city; Reid building, Seventh avenue and Sterling street, Brooklyn; the State asylum, at Matteawan; the New York State asylum and City opera house, Ogdensburg; and in the Dominion Parliament buildings at Ottawa, Canada.

Hammond. St. Lawrence County.— Sandstone is quarried at three localities in the town of Hammond, and on the line of the Rome, Watertown and Ogdensburgh railroad. The stone lies in beds which dip about 5° eastward and, owing to the well-defined joints and the evenness of the bedding, blocks are worked out readily which are suitable for cutting into curbing and flagging stone, or for making paving blocks. Its color is gray-white — in places striped, red and white. It is hard, and is nearly all silica. Unlike the quarries at Potsdam there is little earth covering, and the beds worked are not deep.

The output of the Hammond quarries is nearly all consumed in street work, and goes to Utica, Syracuse, Rome, Binghamton, Ogdensburg and to western cities.

Clayton, Jefferson County.— The Potsdam sandstone formation crops out at Clayton, and affords a hard and durable stone for local demands.

Hudson River Group

Highland, Ulster County.— Quarries on the river bank, two miles north of Highland station, were formerly worked extensively.

Rhinebeck, Dutchess County.— The New York Central and Hudson River Railroad Company continues work at its quarry, a half mile south of the station.

New Baltimore, Greene County.— The sandstone is here on edge, and is generally in thick beds, interstratified with a black, shaly rock. The quarries are not worked to the same extent as in former years. The stone is dark-gray to slate-colored. Much stone has been obtained here for the Hudson river dyking and for dock-filling.

Troy, Rensselaer County.— Sandstone is quarried on Pawling avenue, near the Memorial church, and on Fourth street, near and south of the Poestenkill. It is used for foundations and common wall work in the city, exclusively. And the quarries are in operation at such times as the demand for stone requires.

Aqueduct, Schenectady County.— Three quarries have been opened at this point. The stone is gray to blue in color and fine-grained. It is known in the market as "Schenectady bluestone," and is used in common wall work in Albany, Cohoes and Troy.

Stone with natural-face (joint) surfaces and even-bedded is broken into rectangular blocks and is used in ashlar-work. Some of the older stone buildings in Albany have their walls of these natural-face blocks.

Schenectady.— Shears & Dunsbach have a quarry on the canal, one mile east of the railroad depot, which is the source of supply to a large extent, for stone used in the city, although shipments are made to Albany, Waterford, Cohoes, Troy, Mechanicsville and Saratoga.

This stone can be seen in the Memorial hall of Union university and in the East Avenue Presbyterian church;

in the new armory, Albany; in the church at Menand's station, and in St. Patrick's Roman Catholic church in West Troy. The stone has a bluish shade of color and is fine-grained.

Duanesburgh, Schenectady County.— A quarry in a bluish-colored sandstone, probably of the same geological horizon as that of the Schenectady quarry, is here worked by Albert Shear & Co. The stone is rather coarse-grained but is stronger than the Schenectady bluestone.

The shaly nature of much of the Hudson river group of rocks in the Mohawk valley, west of Schenectady, and the accessibility of good limestone for building purposes, has prevented the opening of quarries in it. Further west, and near Rome, there are small quarries which are referred to this horizon, but they are unimportant. The sandstone quarries in the towns of **Camden, Oneida County,** and of **Orwell,** in **Oswego County,** belong in it. The stone is generally gray in color, fine-grained and hard, and in moderately thick beds. None of these quarries do much more than a small local business; and they are not in operation all of the working season of the year.

Good building stone of the Hudson river horizon is said to have been obtained at quarries south-east of **Rome**; also at **Woodruff's, Oneida County.***

Sandstone of the Medina Epoch

Oswego, Oswego County.—Quarries for the supply of stone for foundation and retaining walls in the city, are opened on the lake shore, east of the Fort Ontario grounds.

Oswego Falls, Oswego County.— The river cuts through the sandstone here and offers facilities for small quarrying operations in the bluffs on the left bank. A dark-red sandstone is obtained under earth and shaly rock. The First Presbyterian church in Syracuse is an example of badly se-

* Survey of the Third Geological District, Lardner Vanuxem, Albany, 1842, p. 261.

lected stone and set on edge in many cases. A great deal of it has been used in Fulton, Oswego and Syracuse.

A specimen from the quarry of Hughes Brothers of Syracuse was found to have a specific gravity of 2.62, and an equivalent weight of 163.5 pounds to the cubic foot. It contained 0.59 per cent of ferrous oxide, and 1.71 per cent of ferric oxide. The absorption test gave as a result 3.53 per cent. It lost weight in the treatment with acid solutions. In the freezing and thawing it checked badly, and at a high heat its color became brick-red, and its strength was impaired.

Granby, Oswego County.— The Granby Brownstone Company, O. J. Jennings, manager, works the quarry on the line of the Delaware, Lackawanna and Western railroad, two miles south of Fulton. The stone is fine-grained, purplish-red in color, and admits of fine-tool dressing. It has been used in the following structures in neighboring towns and cities: Second National Bank building, Oswego; Protestant Episcopal church, and a block of stores in Cortland; and new Jewish synagogue, Buffalo.

Small quarries are opened westward in this formation at

Camden, Oneida County
Sterling, Cayuga County
Wolcott, Wayne County
Penfield, Monroe County

At **Rochester** the gorge of the Genesee river exposes to view a fine section of the formation. Formerly some stone was obtained from quarries in the river bluffs. In Monroe county generally this sandstone is too argillaceous to be durable.*

What is more particularly known as the Medina sandstone district, is that portion of the outcrop which extends from Brockport in Monroe county west to Lockport. The belt is narrow, and the quarries are opened in it near the Erie canal. They are grouped here as follows:

* Prof. Hall's Report on the Survey of the Fourth District, Albany, 1843, pp. 432–3.

Brockport, Monroe County
Holley, Orleans County
Hulberton, Orleans County
Hindsburgh, Orleans County
Albion, Orleans County
Medina, Orleans County
Shelby Basin, Orleans County
Lockport, Niagara County

Brockport.— Two quarries are opened at this place.

Holley, Orleans County.— There are five quarries at Holley. Those of Downs & Gorman, Michael Slack, and O'Brien & Co., Fletcher & Sons, and the Big Six Stone Company are near the canal and the New York Central railroad. The beds lie nearly horizontal, and under a light stripping of earth and boulders. The stone is of a light red color and fine-grained.

The output is largely in the form of blocks for street paving, curbing, crosswalks and gutter-stone.

Rochester, Buffalo, Syracuse, and western cities, as far as Kansas City, are markets.

Hulberton, Orleans County.— This group of quarries is west of the village, on the north side of the canal, stretching along a distance of two and a half miles.* They are all worked to a depth below the canal water-level, and pumping is necessary to drain them. The stripping of drift-earth does not exceed ten feet. Some of the beds are thick, and blocks of large size are obtained. The stone is mostly fine-grained, and light to dark-red in color. The best quality is shipped for building stone. The greater part of the product is split into paving blocks and crosswalks and curbstone, which are shipped to Rochester, Buffalo and western cities.

Much of the Hulberton stone is sold under the name of

* Sturaker & Sullivan, Thomas Lardner, R. O'Reilly, A. Squire, L. Cornell, C. Van York, C. S. Gwyn, M. Scanlon, Hebner Brothers, George Hebner, E. Fairhen and —— Ford have quarries here.

Medina block. Examples in constructioa are the Delaware Avenue Methodist Episcopal church, Buffalo, and Sibley college, Cornell university, Ithaca.

Albion, Orleans County.—The largest quarries of Medina sandstone are at Albion. They are east of the town, between the canal and the New York Central railroad. The parties here at work are: Goodrich and Clark Stone Company; Albion Stone Company, and Gilbert Brady. The stripping on the sandstone is from three to fifteen feet thick. The beds dip a few degrees to the south, and are of varying thickness from a few inches up to six feet. Regular systems of joints facilitate greatly quarrying operations. There is considerable variation in the nature of the stone in the several beds, and even in the same bed, as followed in the same quarry. Generally it is of a light red color, and fine grained.

A specimen representing the best building stone, as quarried by Mr. Brady, has a specific gravity of 2.598, and a weight (calculated) per cubic foot of 162 pounds. The percentage of oxide of iron is comparatively low, being 0.51 and 0.09 for ferrous oxide and ferric oxide, respectively. The absorption test gave 2.37 per cent. The losses in weight, in the tests with carbonic acid gas and sulphurous acid gas, were 0.09 and 0.29 per cent. The treatment with sulphuric acid, 1 per cent solution, occasioned a loss of 0.08. The alternate freezing and thawing produced no visible effect. After a subjection to a high temperature and sudden cooling, the strength was but little impaired and the color was slightly changed.

These quarries employ from one hundred and fifty to two hundred men, each, and the aggregate product, annually, amounts to many thousands of tons. The bulk of the stone quarried by the Albion Stone Company, and the Goodrich and Clark Stone Company, is used for street purposes, as paving, curbing, gutters and crosswalks. Platforms of large

10

size, and smooth and true surfaces, are cut from some of the thick beds.

The paving blocks are sold principally to western cities — Erie, Akron, Cleveland, Toledo, Columbus, Detroit, Chicago and Milwaukee. The Brady quarry produces stone for building, principally.

These quarries are conveniently located for working, at the side of canal and railroad, and are well equipped for large business.

Some examples of the Albion stone are the Presbyterian church, Albion; the Iroquois hotel, Young Men's Association building and Trinity Protestant Episcopal church, in Buffalo; Guernsey building, No. 160 Broadway, New York city; steps of the new staircase, capitol in Albany.

[For other examples, see notes on stone construction in cities.]

Medina, Orleans County.— Medina has given name to this sandstone formation because of its development and the characteristic fossils, which are abundant in some of the gray beds, at this locality. Within a mile and a half of the railroad station there are; north and north-east of the town, Kearney & Barrett, A. M. Holloway, Sara J. Horan, Buffalo Paving Company, Noble & Lyle and C. A. Gorman owning quarries. The working season is naturally from the first of April to the middle of November. The rest of the year is is given to stripping off the overlying earth and waste rock. As compared with the stone of the quarries in the Medina sandstone formation, eastward, the color is lighter gray, and there is the varigated, or spotted red and white, and a light-red. Generally it is harder. Oblique lamination in the beds is more common than at Albion or Hulberton. Pyrite-coated seams and joint faces are seen, more in the older quarries, now idle. Formerly, the light-colored, gray stone was in demand, and was quarried for building; now, nearly all of the gray variety is split into paving blocks, and the fashion for building calls for the red and

the varigated stones. At the extreme north-east the Noble & Lyle quarry produces a reddish-brown stone which is more like the Hulberton stone, and is rather softer than that of the quarries to the west and south-west. It is used for building almost exclusively. In this quarry, and in some of the others, a red, shaly rock, known here as "red horse," is found under the quarry beds, which is waste, The dip is south at a small angle; a regular system of vertical joints runs an east-west course, with a north-south system, less well defined. The total thickness of quarry beds is in places as much as thirty feet, and the range is from two inches to six feet. The larger part of the aggregate production of these quarries is put into street material. The chief markets are Syracuse, Rochester, Buffalo, Erie, Cleveland, Columbus and Toledo, Detroit, Milwaukee, and as far west as Omaha and Kansas City.

Lockport.— Quarries in the Medina sandstone formation were opened near the town, to the north, as early as 1824, and much stone was put in buildings, which are good examples of its durability. The quarries are on the right bank of the Eighteen Mile creek, and are connected with the New York Central railroad by a branch road one mile in length. Stone for flagging, paving blocks, and for building is obtained. Gray, red and mottled varieties occur in these openings. Formerly these quarries furnished stone to outside buyers; at present, they are worked almost exclusively for the local market.

Lewiston, Niagara County.— The same formation has afforded some building, and some flagging-stone at this locality.

Hamilton and Portage Groups

Hudson River Blue-stone

The term "Hudson River Blue-stone" is used to designate the blue, fine-grained, compact and even-bedded sand-

stone, which is so largely employed for flagging and house trimmings in New York city, and to some extent in all of our middle Atlantic coast cities and towns. "The belt of country in which it is quarried is nearly one hundred miles long in New York, stretching from the south-western towns of Albany county, across Greene and Ulster and the western part of Orange and eastern part of Sullivan counties to the Delaware river. In Albany and Greene counties it is narrow, as also in Saugerties in Ulster county, making the foot hills, as it were, on the east and east-south-east of the Catskill mountains, and bounded on the east by the older limestone formations. It widens in the towns of Kingston, Woodstock, Hurley, Olive and Marbletown, and in them the quarries are distributed over the 500-foot plateau which borders the mountains on the south-east. To the north-west, and in the valley of the Esopus creek, many localities near the line of the Ulster and Delaware railroad have been opened and worked. They are a part of the blue-stone district geographically, although the geological formations are not the equivalent of the main belt at the south-east. There are scattering localities in the towns of Rochester and Wawarsing and thence south-west, in Sullivan county which furnish blue-stone for local markets, and for exportation where they are situated near enough to lines of shipping."

The belt, as above described, has in it outcrops of shales and sandstones, belonging to the several geological formations, from the Hamilton period to and including the Catskill, in short, rocks of the Upper Devonian age. There are quarries along the Hudson river at New Baltimore, and thence southward, at Coxsackie and Catskill and near Rondout, but they are not in the typical blue-stone, but in the sandstone of the Hudson river slate formation. The quarries of Palenville and vicinity, of West Saugerties, High Woods, Boiceville, Phœnicia, Woodland Hollow, Shandaken, and Pine Hill are above the horizon of the Hamilton formation and probably all in the Catskill group of rocks. The

Oneonta sandstone, which is the equivalent of the Portage group, may form a part of the belt near the foot of the mountains, but it is impossible to define its limits and to designate the quarries in it. The quarries at Roxbury and Margaretville and their vicinity, are in the Catskill formation. And the openings along the Monticello railroad, in Sullivan county, are probably in the same horizon. The main blue-stone belt, where it has been so extensively opened, as in the towns of Saugerties, Kingston and Hurley, is of the Hamilton period.

"Beginning at the north-east, there are small quarries at Reidsville and Dormansville, seven miles west of the Hudson river, and in Albany county. They have furnished a great deal of stone for flagging in the city of Albany. The stone of these quarries is gray in color and rather coarser-grained than the typical blue-stone of the Hudson river quarries.

"In Greene county there are several small quarries near Leeds, which are worked mainly for the Catskill market. In the vicinity of Cairo stone is quarried at several places, and shipped by rail. On the line of the Stony Clove and Catskill Mountain railroad, and along the Kaaterskill railroad, quarries have been opened, from the mountain houses southwest to Phœnicia."

Ulster county is the largest producer of blue-stone, and its quarry districts are the following: Quarryville, West Saugerties and High Woods, in the town of Saugerties; Dutch Settlement, Hallihan Hill, Jockey Hill, Dutch Hill and Stony Hollow, in the town of Kingston; Bristol Hill, Morgan Hill, Steenykill and West Hurley, in the town of Hurley; Marbletown, Woodstock, Broadhead's Bridge, Shokan, Boiceville, Phœnicia, Woodland Hollow, Fox Hollow, Shandaken, Pine Hill, and Rochester and Wawarsing quarries, in the valley of Rondout creek and its tributaries.

There is much variation in the several quarries of these localities, both in the nature and thickness of the overlying earth or stripping, and in the number and thickness of the

workable quarry beds. A large number of quarries have been opened, and at many places the valuable stone has been removed and the quarries abandoned. At other localities the thickness of the overlying earth and the long distance from transportation lines have prevented their further development. The tendency of later years has been to open quarries nearer the lines of railroad, and to leave localities more distant, so that the number of quarries in the territory adjacent to the Ulster and Delaware road has been greatly increased. The aggregate output of this part of the territory has not materially increased within the last few years, in consequence of the abandonment of many quarries and the restrictions placed upon the quarry industry by the business relations to which it is subject.

The quarry beds range from an inch to three feet and, in some instances, up to six feet in thickness. The top beds are generally thin. In most cases these thick strata can be split along planes parallel to the bedding and the cap-layer is raised by means of wedges. The size of blocks obtained is determined by the natural joints which divide the stone vertically. Stones sixty feet by twenty feet have thus been lifted from a bed. The facilities for handling and lifting really limit the size. The thicker stone are cut into curbing, crosswalk and sidewalk stones and large platforms, yielding what is known as flag-stone. The thinner beds furnish flagging for towns and villages. A part of the thinner stone is cut into dimension work for water-tables, sills, lintels, posts and window-caps or house trimmings in general.

"The stone obtained in these several districts varies in color, hardness and texture and consequently in value, from quarry to quarry, and even in the same quarry. In nearly all of the localities the beds vary a little from top downwards; rarely is there much variation horizontally, or in the same bed. Hence, any given bed may be said to have a certain character, that is, produces a given grade of stone.

The color is predominantly dark-gray or bluish-gray, and hence (more by contrast with the red sandstones) a "blue-stone." Reddish-brown and some greenish-gray stones occur in the quarries higher in the mountain sides, as in the valley of the Esopus creek above Shokan and in the Palenville quarries. There is a decided preference for the typical "blue-stone" over the reddish or brownish-colored grades. In texture the range is from the fine shaly or argillaceous to the highly siliceous and even conglomeratic rock. The best blue-stone is rather fine-grained and not very plainly laminated, and its mass is nearly all silica or quartz, which is cemented together by a siliceous paste and contains very little argillaceous matter. Hence, the stone is hard and durable and has great strength or capacity of resistance to crushing or compression. Coarse-grained sandstones and even fine conglomerates occur and are quarried in some localities. These sandstones are not often found loosely cemented together and friable; and they are rarely open and porous."

A representative specimen of the best Hudson river blue-stone, and obtained from the Bigelow Bluestone Company of Malden, was subjected to a series of tests, with the following result: specific gravity, 2.751; weight per cubic foot, 171 pounds; ferrous oxide, 4.63 per cent; ferric oxide, 0.79 per cent; water absorbed, 0.82; loss in dilute sulphuric acid solution, 0.20 per cent; alternate freezing and thawing, unchanged; at temperature of 1200°–1400° F. color changed to dull red, slightly checked and strength somewhat impaired.

"The blue-stone territory south-west of Ulster county is confined to a narrow belt crossing the towns of Mamakating, Thompson, Forestburgh and Lumberland in Sullivan county, and Deerpark in Orange county. And there are quarries near Westbrookville, near Wurtsborough, along the Monticello railroad and on the Delaware river at Pond-Eddy and Barryville."

Flag-stone is obtained along the lines of the New York, Ontario and Western railroad, and of the Ulster and Delaware railroad at Westfield Flats, Trout Brook, East Branch, Margaretville, Roxbury and Grand Gorge. All of these quarries are in the Catskill group of rocks, and the stone from them is more generally a reddish or brown-tinted sandstone.

It is more open-grained and not so dense and strong as the best Ulster county stone. It reaches the market with the product of the Ulster county quarry and is included in the blue-stone production. The principal shipping points whence blue-stone comes to market are Malden, Saugerties, Kingston (including Wilbur and Rondout). A great deal of stone is cut for house trimmings, in mills in Malden, Broadhead's Bridge, West Hurley, Wilbur, Kingston and Rondout, but the larger number of feet is sent into market simply quarry-dressed, for flagging and curbing. Its superiority as a flagging-stone is recognized generally by residents of New York city and adjacent towns where it has been so extensively used.

"It is so compact as not to absorb moisture to any extent, and hence soon dries after rain or ice; it has the hardness to resist abrasion and wears well; it is even-bedded, and thus presents a good and smooth natural surface; and it has a grain which prevents it becoming smooth and slippery as some of our granites, our slates and our limestones, when so used in walks. It is strong, and is not apt to get broken. But owing to the many thin beds and the use of too thin stones, sidewalks often become unsightly and bad because of breaks, a fault common to all flag-stone when laid in such thin beds or blocks.

"For use in houses and business buildings Hudson river blue-stone is having an increasing market. It is admirably adapted for lintels, window-caps, sills, door-steps, water-tables, etc., with brick, both because of its strength and its durability. None of our sandstones from other districts,

and not even our best granites, are as strong to resist transverse pressure or strain. Tests (comparative) show that it is fully three times as strong, in this way of resistance, as granite, marble, Ohio sandstone and Connecticut and New Jersey brownstones. To resist compression it is not much superior to these sandstones, and not equal to the best granites. And its strength against transverse strains fits it for lintels, sills, caps, and water-tables especially."

Oxford, Chenango County.— The F. G. Clark Bluestone Company, successor of F. G. Clark & Son, has the large quarry on the north-west of the village, and in the hillside west of the Chenango river.

The strata are horizontal, and thin at the top; below, the thick bedded "liver rock" is found, from which blocks of large size are cut. The stone is blue, fine-grained and homogeneous in texture. Its specific gravity is 2.711, and its weight per cubic foot 168.9 pounds. The absorbed water was found to be 1.11 per cent. It was not materially affected by the freezing and thawing tests. At a high temperature — 1200°–1400° F., the color was changed to dull red, and the stone was checked badly.

A partial analysis showed the presence of 3.46 per cent and 0.16 per cent of ferrous acid and ferric acid respectively. A crushing test of the strength of this stone, made in 1884, showed a resistance of 13,472 pounds to the square inch.

Architects and builders object to this stone in common with other blue-stone, for work in which there is much carving and fine tooling, on account of its hardness and the greater expense involved in working it, as compared with softer sandstones and limestones.

The plant includes a planer, rubbing-bed and three gangs of saws, driven by steam power, besides quarrying machinery proper.

The principal use is for house trimmings and large platforms and steps. During the quarrying season one hundred and fifty men are employed, and in 1889 one thousand four

hundred car-loads of stone were shipped. The market is in the cities of the eastern states.

The lower portion of Aldrich court, 41–43 Broadway, the steps, residence of Cyrus Clark, Riverside avenue and Ninetieth street, New York; steps in the terrace approaching the capitol, Washington, District of Columbia; steps, platforms, and column-bases of capitol, Trenton, New Jersey; St. Lawrence hall, New Haven, Connecticut; part of state prison for insane criminals, Matteawan, New York, are some of the examples of construction in which the Oxford blue sandstone has been employed.

Small quarries producing flagging-stone, mainly, are opened at

South Oxford, Chenango County
Coventry, Chenango County
Smithville Flats, Chenango County
Guilford, Chenango County
Oneonta, Otsego County
Cooperstown, Otsego County

They are worked at irregular times as demand calls for stone.

Trumansburgh, Tompkins County.— In the vicinity of Trumansburgh there are twenty or more quarries which produce four hundred thousand square feet of flagging annually. Two of them only do a little business in building stone, the quarries of F. C. Biggs and of the Flagstone and Building Stone Company. That of the latter is one mile east of the village and less than a mile from Cayuga lake. The grayish-bluestone of the lower course of the quarry is fine-grained, and is cut into lintels, sills and curbing at the company's works at Cayuga, or shipped to their yards at Mott Haven, New York.

The Biggs quarry is on the Taughannock creek about two miles west of the lake and near the Geneva, Ithaca and Sayre railroad line. The stone here is known as the blue sandstone and resembles in appearance the Hudson river

blue-stone, but is harder to work and apparently a little more dense. Stone from this quarry is seen in the large vault in Grove cemetery, Trumansburgh. A part of the product is monumental bases.

The stone from these quarries is carried by boats to Cayuga, whence it goes to New York and to cities in the central and western part of the state.

Ithaca, Tompkins County.— Nearly all of the stone for foundations and retaining walls, and much of the flagging-stone used in Ithaca, comes from local quarries. There are two quarries on the hill south of the town whence flagging-stone is taken. Some of the stone for the university buildings was quarried on the university grounds. The sandstone of these quarries is of a greenish-gray shade of color, fine-grained, and is durable, when selected with care. The natural-face blocks are often rusty-looking, ironstained, or dirty-yellow. Cascadilla hall is an example of the best of it.

Sandstone of the Clinton Group

This formation furnishes a building stone in Herkimer and Oneida counties, and quarries are opened in the towns of Frankfort, New Hartford, Kirkland and Verona. The city of Utica uses the greater part of the stone from the quarries at **Clinton** and those on **Frankfort Hill.** The stone of the latter place is dark-gray and red-brown in color, medium fine-grained and hard, so that dressing is costly. It is used for foundations and common wall work, mainly. Grace Protestant Episcopal church, on Genesee street, and the Lutheran church, on Columbia street, are built of this stone.

Sandstone has been extensively quarried at **Higginsville, Oneida County,** by a Utica company. It is dark-gray and olive-green in color; hard, and dressed with difficulty. Some of this stone has been used in Rome. Fine examples of it are the Baker and Gilbert houses, on Genesee street, Utica.

Watkins Glen, Schuyler County.— Sandstone of the Portage group is here opened and worked by the Northern Central Railroad Company, for its construction on lines north and south.

Penn Yan, Yates County.— Sandstone for foundation work is quarried near Head street, and on the east side of the lake, three miles north of the village.

Portage, Livingston County.— The Portage Blue Stone Company's quarry is on the west side of the Genesee river, two miles south of Portageville and three miles from Portage station, on the New York, Lake Erie and Western railroad. The Buffalo, New York and Pennsylvania railroad line is a few rods east of the quarry. The quarry beds have a total thickness of twenty-five feet. The best stone is olive-green in color, fine-grained, homogeneous in texture, and soft enough to dress well and to be easily cut. It is said to harden on exposure to the weather. A representative specimen from this quarry was found to have a specific gravity of 2.695 and equivalent to a weight of 168 pounds per cubic foot. The absorption test indicated 2.97 per cent of water absorbed; treated with dilute solution of sulphuric acid the loss amounted to 0.42 per cent; freezing and thawing tests produced slight scaling. In the test, at a temperature of 1200°–1400° F., the color changed to dull red. There were no checks, and the strength of the specimen was but little impaired.

The greater part of the stone quarried here is shipped to New York city, where it is worked up into house trimmings. Some of it is sent to Rochester, where it is cut into dimension stone at the Pitkin yard. The Aldrich Court building, Nos. 41 and 43 Broadway, New York, has Portage stone in the trimmings, in the first and second stories. Some of this stone was used in the United States Government building, at Binghamton.

Warsaw, Wyoming County.—There are two sandstone quarries near this place. The Jameson & Warsaw Manu-

facturing Company's quarry is two miles west of Rock Glen, on the New York, Lake Erie and Western railroad. It was opened many years ago, but was idle in 1888–9. Some of the stone in the city hall, Rochester, was taken from this quarry. The Warsaw Blue Stone Company's quarry is located one-half mile from Rock Glen station, and south of Warsaw; a side track runs from the quarry to the main line of the New York, Lake Erie and Western railroad. The Warsaw bluestone is very fine-grained, harder than the Ohio sandstone, and retains its color on exposure. It has been used for more than thirty years, in Warsaw and vicinity, for monumental bases and buildings.

A specimen from the company's quarry showed a specific gravity of 2.681, equivalent to a weight of 167 pounds per cubic foot. It contains 3.22 per cent of ferric oxide and 0.23 per cent of ferrous oxide. The absorption test gave as a result 2.99 per cent; the freezing and thawing tests produced slight checking. At the high temperature (1200°–1400° F.), there was a slight vitrification, somewhat of checking, and the color was changed to dull red. The quarrying plant has been largely increased, and the machinery for sawing and dressing the stone has been set up. The output during the year 1889 was largely in excess of that of any previous year. The principal use of this stone is for house trimmings. The markets are New York city, Syracuse, Elmira, Corning, Binghamton, Philadelphia and Washington. The Alpine, corner of Sixth avenue and Thirty-fourth street, New York city, the United States Government building, Binghamton, and the Colgate Library building, Hamilton college, are more prominent examples of the Warsaw bluestone.

Chemung Group

Waverly, Tioga County. — Two quarries are opened and worked at intervals in the vicinity of this place. The stone

is blue to gray and rather fine-grained. It has been used in bridge building on the line of the Delaware, Lackawanna and Western railroad, and in several business blocks in Waverly and vicinity.

Elmira, Chemung County. — Four quarries have been opened in the sandstone in the western face of the hill which here bounds the valley. The stone is fine-grained, and has a gray and greenish-gray color. It is all sold in the rough and used in Elmira for common wall work, and some of it for curbing. The average cost is about $1 a perch in the city.

Corning, Steuben County.— There are four quarries in the sandstone at Corning, in the southern outskirts of the town. The stone of these quarries is generally fine-grained, and of a grayish color. It is hard, durable, and does not absorb much moisture, but in consequence of flinty-like seams in it, it cannot be dressed or fine-tooled economically. The natural-face blocks are often weathered dirty yellow or brown and hence the need of careful selection of stone. For ordinary wall work and foundations, it answers well. The Corning stone has been used in Elmira, in the Congregational church and in the State Reformatory buildings. In Corning, the old arsenal, built about thirty years ago, the Roman Catholic, Protestant Episcopal and First Presbyterian church buildings are all of this stone. The best example can be seen in the basement-wall of the high school, and in the basement of the residence, near the public school, in which work great care was taken to select large stones and of uniform shade of color.

Dansville, Livingston County.— Sandstone for building purposes and for street work is obtained from the quarry, one mile north-east of the village. The stone is bluish-gray in color, fine-grained and hard, but accompanied by much waste rock.

The Chemung sandstone is opened in Steuben county at Cohocton, Bath, Hornellsville, and in the town of Green wood.

At the **Cohocton** quarry the output is all cut into flagging, which is used in the adjacent towns.

In the town of **Bath** two quarries are worked. The stone is of a light-gray color, fine-grained and rather hard. Curbstone, flagging and common wall stone, are obtained from these quarries. The county buildings and the Protestant Episcopal and Baptist churches are built of this stone.

Two quarries are opened and worked in the vicinity of **Hornellsville.** The stone has a bluish color, is hard and fine-grained. The product of these quarries is mostly common building stones, and is cut at Hornellsville. The Park school-house, the electric-light building and several stores and residences are built of it.

In Allegany county, sandstone quarries are opened at Belmont, at Belvidere, near Belfast, and in the towns of New Hudson and Cuba. The **Belmont** quarry affords a light-blue stone, which, when cut, has a light-gray shade, and is rather soft and easily dressed. The principal markets are Belmont, Wellsville and Angelica. Vanderhoef's block, in Belmont, besides other buildings, are of this stone.

The **Belvidere** quarry is worked in a small way, mainly for the local market. Some of the stone is used at Friendship, Angelica, and a little of it in Wellsville and Hornellsville.

Two miles south of **Belfast** sandstone is quarried to a limited extent for a supply of the town. The Baptist church is constructed of this stone.

Flag-stone is quarried in the town of **New Hudson,** near the west line of Belfast. The quarry is worked to a small extent, and its output is considered the best in this part of the State.

Olean, Cattaraugus County.—The Olean Blue Stone Company quarries a sandstone two and a half miles south of Olean, and about seven hundred feet above the Alleghany river. Stone for building and flagging is obtained and is put on the market as "Olean bluestone." It goes to Buf-

falo and Rochester. The stone is fine-grained and has a greenish-gray shade of color.

Jamestown, Chautauqua County.— There are six small quarries in the eastern part of the town, near the lake outlet. Bedded with the quarry stone there is much shale, and consequently a great deal of waste material has to be removed in quarrying. The bottom beds, from twelve to twenty inches thick, furnish stone for cut work. The stone of the upper strata is used for rubble work. The Jamestown stone is olive-green in color, fine-grained, soft and breaks with a conchoidal fracture. It has had an extensive use at Chautauqua and in Jamestown, both for foundations and retaining walls and for house trimmings.

Other localities in Chautauqua county are in **Panama**; in the town of **Clymer**; in **Westfield,** near Lake Erie; and at **Laona,** in Pomfret. The quarries at these places are too small and comparatively unimportant for general description.

Triassic or New Red Sandstone

Nyack, Rockland County.— Two quarries, located on the shore of the river, are worked more or less steadily; one by Daniel T. Smith, the other by Nelson Puff. The stone of these quarries is worked into lintels, sills and platforms. The product is mainly for the local market.

Haverstraw, Rockland County.— The sandstone quarries at Haverstraw are worked only at long intervals, and then for common building stone which is used in the place.

Formerly these Nyack and Haverstraw quarries were worked on a large scale, and stone for building was shipped thence to New York and cities along the Hudson valley.

The house still standing near the Smith quarry, which was built in 1768, shows the durable nature of the stone. The Cornelius house in Nyack is another example.

Slate

Argillyte or clay-slate, which is marked by the presence of cleavage planes, and can be split into thin plates of uniform thickness — roofing-slate — is a characteristic rock in the Hudson river group, or Hudson terrane. Shales, sandstones and fine siliceous conglomerates are often associated with the slates.

The formation occupies the valley of the Wallkill, in Orange county, the Hudson-Champlain valley, from the Highlands north to Lake Champlain, and the Mohawk valley and a belt west and north-west, to Lake Ontario.

Slate suitable for roofing has been found in many localities, and quarries have been opened in Orange, Dutchess, Columbia, Rensselaer and Washington counties. The openings in Orange county have not resulted in productive quarries. In Columbia county quarries were worked many years ago, east of New Lebanon.* The Hoosick quarries, in Rensselaer county, were more extensively worked, and produced a good, black slate. Outcrops of red slate are noted east of the Hudson, from Fishkill and Matteawan northward, but no attempts have been made to open quarries in them.

The productive slate quarries of the state are in a narrow belt, which runs a north-north-east course through the towns of Salem, Hebron, Granville, Hampton and Whitehall, in Washington county.

This slate belt is divided by the quarrymen into four parallel ranges or "veins," which are: East Whitehall red slates; the Mettowee, or North Bend red slate; the purple, green and variegated slates of Middle Granville; and the Granville red slates. The latter is close to the Vermont line. Further to the east, but over the state line, in Vermont, is the range of the sea-green slates.

---

* Wm. W. Mather, Geology of the First Geological District, Albany, 1843, pages 419-421.

The quarry localities are at Shushan; Salem; Black creek valley, in the town of Salem; Slateville, in Hebron; Granville; the Penrhyn Slate Company's quarries, Middle Granville; Mettowee or North Bend quarries; and the Hatch hill quarries, in East Whitehall.

The quarries of Washington county have not yet been worked down to as great depth as some of those in Northampton and Lehigh counties, in Pennsylvania; and the deepest has not reached a vertical depth of one hundred feet.

The quarries at the south-west, in Shushan and Salem, produce purple, variegated, and green colored slates. At Salem some stone for flagging and foundation work is obtained. At the quarries west and north-west of the village of Salem, and at Slatesville, in Hebron, the slate is red.

The principal range of red slate is that which runs from Granville north — passing east of Middle Granville. It is narrow, being in places less than thirty rods wide. There are numerous openings in it, and it has yielded a large amount of red, and some unfading-green, roofing slate.

In Middle Granville the purple, green and variegated varieties are found. North of the village, a quarter to three-quarters of a mile, are the large openings of the Penrhyn Slate Company, which produce purple, unfading-green, and variegated (green and purple) slates. A large part of the output of these quarries is worked up in their mills into plain, marbleized, decorative and enamelled material, as mantels, steps, house trimmings, table tops, laundry tubs, wainscoting and floor tiles.

The Mettowee or North Bend quarries, three and a half miles north of Middle Granville, are worked by two companies. Their product is a red roofing slate.

The Hatch hill group of quarries is six miles south-east of Whitehall. There are four openings.

The slate is of a bright-red color. A part of it is split at the quarry into roofing material. Perhaps an equally

large amount is cut into floor-tiling, billiard-table tops, and house trimming materials. These quarries are much deeper than those of the Granville red slate range, and the slate has a brighter red color, and is more easily worked than that of the latter range.

Their product, mostly finished stock, has to be carted by teams, six miles to Whitehall, or to Middle Granville, shipping points.

The green slate of these Washington county quarries is almost all of the unfading variety, which is more durable and more valuable than the sea-green slate. The variegated (purple and green) also is durable, but is softer and less valuable than the red, which is esteemed for roofing and tiling purposes.

The purple and green slates are more abundant, and are used more for marbleizing.

A specimen of the red roofing slate of Washington county was tested and found to have a specific gravity of 2.84, equivalent to a weight of 177 pounds per cubic foot. It contained 1.87 per cent of ferrous oxide and 7.36 per cent of ferric oxide. Its absorptive percentage was 0.15. It lost 0.07 per cent in weight in the sulphuric acid solution test. It remained unchanged in tests of alternate freezing and thawing.

The estimated production of red roofing slate in 1889, was 5,000 squares. The ruling prices per square were as as follows: *

Red	$8 00 to $10 00.
Purple..................................	3 50 to 4 00.
Unfading-green..........................	3 50 to 4 00.
Sea-green...............................	2 75 to 3 00.
Variegated..............................	2 50 to 2 75.

* Letter of Hugh Williams of Middle Granville, January 22, 1890.

NOTE.— A recent bulletin of the United States Census gives a list of firms producing slate, and the statistics of production, labor, wages, etc. According to this report there are sixteen quarries in this State, which produced in 1889, 17,167 squares of roofing slate, and slate for other purposes valued at $44,877, making a total value of $130,603.

IV

ON THE USE OF STONE IN CITIES

The outcrops of the geological formations, which contain stone suitable for building, are so extensive and so widely distributed in New York that all of its larger towns and cities have either near, or within their limits, quarries for the local supply. It may be said that every city in the state, having a population of twenty thousand and upward, excepting Brooklyn, is built on rock. And there are stone quarries in nearly all of them, although not all produce good stone. The interior water-ways and the net-work of railway lines afford low rates of transportation and a choice of building stone from many state localities, and from the great stone-quarry districts of New England and of the west. Large amounts are imported from Europe, almost exclusively for construction in New York and Brooklyn. There has been a notably larger use of stone in the cities of the central and western-central parts of the state, as compared with the towns in the Hudson river valley, and the southern tier of counties. Many of the oldest buildings in the older towns and cities are of stone. The later introduction of brick, and the extraordinary development of the brick-making industry, especially in the Hudson river valley, has tended to check the use of stone for ordinary construction ; so much so, that only the larger and more permanent structures are of stone. The increase of wealth, and a better architectural taste, have stimulated the building of expensive stone dwelling-houses, as well as more costly church edifices and other structures for public use. The resources of the state, in its numerous quarries of the most durable as well as beautiful building stone are great, and it is to be hoped that all who are in any wise interested in the beautifying of homes, and in the erection of buildings which are to be of

a permanent character, will help on the development of these natural resources in the greater use of stone. What has been said of the cities of Great Britain applies with even greater force to New York; the "general use of artificial materials has stamped with an aspect of comparative meanness the street architecture of many large cities and towns, such as London, itself, together with Dublin, Birmingham and Manchester, while on the other hand, the employment of stone in the construction of dwelling-houses, as well as the public buildings, has imparted to the cities of Edinburgh, Aberdeen, Glasgow, Brussels, Paris and Rome a character of solidity and beauty which forces itself on the attention of the most careless observer." *

The notes on stone construction in cities of the state are restricted to those having a population of over twenty thousand and are given under their respective headings, arranged in a geographical order, beginning with New York.

New York

The division of the city into districts, which are bounded by well-defined lines and which are marked by distinguishing characteristics in their architectural features and in the use of constructive material, is possible, within certain broad limits, exclusive of many details and with many exceptions. Business is segregated, to a great extent, in certain localities, and on lines which run out from these centers for miles into the residence parts of the city. The latter also are remarkably diverse in the character of their population, and in the style and cost of the buildings in which it is housed. These distinguishing features are apparent in close juxtaposition, and they mark sections whose boundaries are very irregular, and which are in some cases so interlocked as to make a delineation difficult without the aid of illustration by maps, showing their limits. There are,

* Hull; Building and Ornamental Stones of Great Britain and Foreign Countries, London, 1872, page 1.

however, some general characteristics which belong to certain great districts, and afford a basis for a division of the city in accordance with these distinguishing characters. The districts as here given, are as follows :

1. The down-town business district, with its great office buildings, south of Chambers street.

2. The general business district, between Chambers and Twenty-third streets, including the east-side tenements.

3. The older residential district, between Twenty-third and Fifty-ninth streets.

4. The newer or up-town residential district, with its large apartment houses, between Fifty-ninth and One Hundred and Tenth streets.

5. The west-side heights and Harlem, from One Hundred and Tenth street to the Harlem river.

6. The less compactly built and suburban twenty-third and twenty-fourth wards of the city, lying north of the Harlem river.

In the down-town district, as here given, that is, from the Battery to Chambers street, a remarkable transformation is going on in the appearance of that part of the city, and large all-stone or stone and brick structures, eight to thirteen stories in height, are replacing the older brick, iron, and brick and stone-front buildings.

The increased height and more massive walls demand more care in the substructures and stones of larger dimensions than were formerly used. Granites are preferred for the foundations, and are put in the lower story fronts also, with sandstone or limestone in the walls of the upper stories. The number of notable stone buildings in this part of the city is larger than in the other districts, excepting churches, which class is best represented in the up-town districts. Here, also, are the various public buildings of the United States government and the city offices. The substantial character of these newer constructions and the rapid increase in their numbers, points to an increasing demand for the best building stone and in blocks of large size. The

time is not far distant when the whole of this part of the city will be covered with these tall and massive structures, devoted to business purposes.

In what may be termed the general business district, north of Chambers street, the work of reconstruction is going on more slowly than it is down town.

The mercantile and factory buildings, the large hotels and the church edifices west of the Bowery and Third avenue are generally either all stone or stone fronts. On the east side, in the poorer tenement quarters, brick, trimmed with stone, are the prevailing building materials. The private dwelling-houses remaining below Eighth street, on the west side of the city, are, in most cases, of brick with stone trimmings, as are many of the stores on the streets near the river. Connecticut brownstone has been used almost exclusively for fronts in all of the cross streets above Eighth street, and has given them a monotonous aspect, owing to the long lines and blocks of houses in the same unvarying style of construction. Many of these brownstone fronts are being replaced by large business buildings, either all stone, or brick trimmed with stone. A notable change is taking place on Fifth avenue between Fourteenth and Thirty-third streets, and the brownstone is disappearing before the tide of granite, sandstone and limestone coming in with the advance of business up town. In the cross streets, excepting Fourteenth and Twenty-third streets, there is less change noticeable. On Broadway there is a mixed character in the styles as well as in the nature of the materials used; and there is not probably in the world a street where there is greater variety in building material. Iron fronts, brick, marble, granite, and all kinds of stone are seen, sometimes within the compass of two or three blocks. There appears to be an increasing use of stone in the constructive work on this street. The avenues west of Fifth are occupied with large apartment-houses and stores. Brownstone fronts and brick, with brownstone trimmings, prevail. This division of the city is notable for its many large and

costly church edifices. On Fifth, Madison and Park avenues they are particularly large, and constitute a striking feature in the street scenery. Brownstone has been the common material in their construction.

The up-town streets near the park contain many new apartment-houses, built of brick, trimmed with stone. There is, however, an apparent increase in the use of brick in their construction over that of stone, corresponding to the demand for apartment-houses in preference to the older styles of dwelling-houses.

Above Fifty-ninth street and west of Central park, there is an extraordinarily large amount of building in progress and whole blocks of costly houses are in course of erection. The ground is high, the situation between the park and the river is good, and the more eligible sites are held at high prices. They are being occupied by a superior class of dwelling-houses. The style of fronts in these newer houses is much more varied than on Fifth avenue and the streets below the park, and there is a much greater variety of stone used. Instead of rows of houses of the same stone, a common practice in this part of the city is the use of eight or ten kinds of stone in a block, and so that no two adjoining buildings are of the same stone. Limestones thus alternate with sandstones, and these latter are of various shades of color, combining to produce a pleasing effect, and relieve the monotony incidental to the use of a single variety. For these newer constructions Connecticut brownstone is less employed and there is more of the oolitic limestones from Indiana, the red sandstones from Lake Superior, Ohio sandstones, the Longmeadow sandstones, and the blue sandstones from western New York.

East of the park on the cross streets, there is more brick and relatively less stone, excepting for trimmings, but on the avenues more stone is used. And there are more apartment-houses, which may be said to be true of all of the avenues up town.

Above One Hundred and Tenth street, there is a great deal of building in what is known as Harlem, and there are many noteworthy public structures and elegant houses of stone. There is apparently more brownstone used here than in the streets west of the park.

The high ground west of Harlem, and extending northward to the end of the island, is not being built up so rapidly as the level east of it. There are some fine blocks of costly stone dwelling-houses, and many in course of construction. All kinds of stone are used, but the various sandstones and the oolitic limestones are most commonly seen. There are still many frame buildings, and also many of brick, mostly small and inexpensive. The gneissic rocks of the ledges, which are cut by grading for streets or in cellar excavations, have yielded stone for some of the large public institutions on this part of the island.

The number of buildings in the city, as reported September, 1889, by the superintendent of buildings, Thomas J. Brady, of the bureau of inspection of buildings, East Sixty-seventh street, is 120,900. They are grouped in the following divisions, viz.:

1. South of Chambers street	4,817
2. Between Chambers and Houston streets	18,126
3. Between Houston and Twenty-third streets	20,385
4. Between Twenty-third and Fifty-ninth streets	28,127
5. Between Fifty-ninth and One Hundred and Tenth streets	19,767
6. From One Hundred and Tenth street to Harlem river	14,524
7. North of the Harlem river	14,694
8. On the islands in harbor and river	460
Total	120,900

According to an enumeration made by the bureau of inspection of buildings, of the fire department of the city, in 1882, there were in the city 102,624 buildings, of which 73,641 were of brick, stone, iron and other non-inflammable material, and 28,798 of wood and other inflammable material, exclusively. The percentage of stone buildings in

1882, amounted to $11\frac{6}{100}$, of which $89\frac{4}{100}$ per cent were of sandstone.* No recent enumeration has been made of the stone buildings. The proportion of stone and brick structures is probably the same as it was in 1882, as the use of brick has kept pace with that of stone, so far as the number of structures is concerned.

New York is truly cosmopolitan in the world wide range whence it draws its supplies of building materials, and in the great variety which it uses. It is a market in which all of the quarries of our country, and all of the more important quarry districts of the world are represented by their characteristic varieties of stone. It attracts materials from the old and well-developed quarries, and to it the newly opened localities send their samples and solicit its custom. Its situation affords easy water transportation and low freight rates, not only from foreign ports but, also, from the tide-water quarry districts of New England, and many quarries in New York and on the great lakes, which are reached by the canal system of the state and the lake routes. The railway lines also bring large amounts of stone from Ohio, Indiana, Kentucky, Tennessee and points in other western and southern states, at rates which enable the quarry owners to put their stone in New York, at prices which are as low as those of the nearer quarries of the state, and of New England and New Jersey. The active competition of dealers in stone, the large amount called for by the building industries and the many lines of water and land transportation, which converge in the metropolis, combine in bringing together a greater variety of stone and at lower rates of cost than at any other place in the country. And owing to these favoring influences the consumption of stone in constructive work in New York is relatively greater than in the larger cities of the state, and of the adjacent eastern and middle states. Fine examples of the use of stone, either in ordinary constructive or in decorative work, from

*Julien in Tenth Census of United States, Vol. x, p. .

quarries in nearly all parts of the world, are to be found in the city. Some of the larger and more prominent structures which can be considered as representative of the leading kinds of stone in use, and of many quarry districts and localities, are mentioned in a list at the end of these notes on the use of stone in cities.

The proportion in which the chief varieties of stone enter in the annual volume of construction has varied notably in consequence of changes in the styles of architecture, through the necessities of altered conditions and an educated public sentiment which demands variety and a better class of material. As a result the white marbles and brownstones no longer predominate. Granites from all parts of New England and New York, marbles from New York and Vermont, red sandstones from Massachusetts, brownstones from Connecticut and New Jersey, limestones from quarries in the state, Ohio sandstone, the oolitic limestones from Indiana and Kentucky, Portage red sandstone, Hudson river bluestone, Potsdam sandstone, and roofing slate from Pennsylvania, Vermont, and from Washington county, New York, are the stones most in favor and most extensively used.

The recent introduction of many varieties of stone is apparent in the newer and large buildings, especially in the business parts of the city. Wall street and Broadway below Chambers street, afford excellent opportunities for studying the effect of the leading kinds of stone in massive structures side by side or within the limits of a few blocks. In Wall street, the old Assay building and the United States Subtreasury, of Westchester county marble; the United States Custom-house, of Quincy granite; the Drexel building, of white marble from Vermont; and the older brownstone buildings near William and Fulton streets, are offset by the polished granite of the Merchants and Manhattan National bank building; the United States Trust Company's ornate front of Milford granite and Massachusetts red sandstone; the granite and limestone in the front of the Mechanics

bank, and the Bank of America; the Scotch sandstone in the Gallatin National bank, and the Manhattan Trust Company's buildings; and the massive, rock-face blocks of Longmeadow sandstone in the United bank building on the corner of Broadway.

On the lower part of Broadway there are many new and striking architectual constructions in stone, sandwiched in with the older, white marble and brownstone fronts. The Equitable Assurance Company's building, the Standard Oil Company's building, the Welles building, the Union Trust Company's building are among the newer examples of Maine granites. The United bank building, of Massachusetts sandstone; the Consolidated Stock Exchange building, of Scotch sandstone; Aldrich court, of Portage and Oxford sandstone; the New York Post-office, the Field building with its massive trimmings of sandstone from Little Falls, New Jersey; and the Guernsey building, of Medina sandstone from Albion, Orleans county, represent the sandstones now more in favor, and in newer style of construction. The Astor house, of Quincy granite; old St. Paul's church, of gneiss and sandstone; Trinity church, of sandstone from Little Falls, New Jersey; the city hall, the National Park bank, National Shoe and Leather bank building, of white marble; the Merchants' Exchange National bank building, of Dorchester sandstone; and the Broadway bank building, of Connecticut brownstone, are examples in construction of styles and materials of the past rather than the present.

Granite

Granites are used extensively in New York city in the foundations and substructures of the more massive business buildings, and for fronts for the principal and first stories, with Indiana limestone, sandstones, or brick in the upper stories. The Tribune building, the New York Times building, and several of the new bank buildings on Wall street,

and the "Judge" building in Fifth avenue, are some examples of such combinations of granite with other stone or brick. The United States government and the city public buildings are nearly all of dressed granite. The piers, towers and approaches of the New York and Brooklyn bridge, of High bridge, and of the Washington bridge over the Harlem, and bridge work generally, are of granite, largely from Maine quarries. For decorative work the Nova Scotia and the Red Beach, Maine, granites are used to some extent. For interior ornamentation the gray Aberdeen and the red Peterhead (Scotch) granites have been in favor. Of the state quarries the "International Scotch granite," a red variety from Grindstone island, Jefferson county, and the gray Au Sable granite, from Essex county, are being introduced, the first as an ornamental stone, the latter for general construction. The lighter-colored varieties are now preferred for fronts to the dark-colored, as the latter become dingy-looking with age. A favorite combination is the light-gray, porphyritic granite of Milford, Massachusetts, with the red sandstones from East Longmeadow, in the same state.

Granite has not been exposed to the weathering effects of the atmosphere in any of the buildings of the city long enough to yield any data as to its probable limit of endurance. The oldest granite structures are not yet seventy years old, and the stone in them shows scarcely any signs of disintegration, and none affecting seriously its strength.

Gneiss

The gneiss rock outcrops on the island and in Westchester county, furnish a large quantity of common building stone. The stone is obtained mainly in street grading and in excavating for foundations. It is used for rubblework in inner walls, for filling in behind ashlar work and for foundations of buildings. For retaining walls and heavy

masonry, also, it is employed to some extent. As the city advances and covers the outcrops, the localities of supply decrease in number and less of it is used. The more massive constructions of recent years have necessitated the use of stone in blocks of large dimensions, and more of granite and limestone and less of this stone. Many of the older church edifices were built of gneiss. Among the more prominent examples, which may here be referred to, are: the side walls of St. Paul's church, Broadway; St John's Protestant Episcopal church, Varick street (built in 1803–7); St. Matthew's Lutheran church, Broome, corner of Elizabeth street; New York Juvenile Asylum, West One Hundred and Seventy-eighth street and the Forty-second street Croton reservoir. Owing to the laminated structure of the more micaceous gneiss, it is liable to disintegration along the lines of mica and to flake or scale off, when set on edge. And such decay is noticeable in the stone of these older buildings. The necessity of repairs in the case of the more inferior kinds of gneiss makes it undesirable as a building stone, except where it is protected from the action of atmospheric agencies.

Marbles

The use of marbles in the construction of exterior walls was formerly much larger than at present. The opening of the Tuckahoe and other quarries in Westchester county, so near the city, and the erection of several notable white marble buildings in the earlier decades of this century, brought this stone into notice and favor. White marble fronts were in fashion, mainly for business buildings, and Broadway was noted for the number of these "marble palaces." Many residences were built with marble facings. The introduction of sandstones of various kinds, of limestones and granites, has caused a decline in the demand for marble, particularly for exterior construction, and compar-

atively few of the newer buildings are of marble. As can be seen by reference to the tabular statement, appended to these notes on cities, there are many fine architectural illustrations of white marble in New York. The quarries of Westchester county have furnished most of the marble used here. Lesser amounts have come from Massachusetts, Vermont and Maryland. One of the oldest marble buildings in the city is the present United States assay office, built in 1823, of white marble from Tuckahoe. Its surface is somewhat yellow, but the arris edges remain sharp, whereas the Italian marble in the caps of the Doric columns of the front is much weathered and worn. The Stewart building on Broadway is another of the older examples of Tuckahoe marble which is well preserved. The houses of the cardinal and archbishop on Madison avenue, in the rear of St. Patrick's Roman Catholic cathedral, and the hotel on Broadway, corner of Thirty-second street, are among the newer buildings in which the Tuckahoe marble has been put. The city hall is of white marble (excepting the rear wall) from West Stockbridge, Massachusetts. It was much discolored and weathered before it was cleaned, recently. The United States sub-treasury building, also of Massachusetts marble, shows a weathering out of crystals of tremolite and ugly fissures which disfigure the stone. In the comparatively new county court-house, the south walls of the wings, of Sheffield marble, are already discolored and dirty-looking. The Corinthian columns of the front, of Tuckahoe marble, still appear fresh and sharp-angled. The United States hotel, corner of Fulton and Pearl streets, shows much decomposed and wasted surface. It was built in 1823, of Westchester county marble. Grace church, Broadway and Tenth street, built forty-five years ago, of the same stone, has become bluish-gray in color and the surfaces of the block are much roughened by the weathering. Vermont marbles are noted in the Collegiate Reformed church, Fifth avenue, corner of Twenty-ninth street, and in

the Drexel and Morgan building, Wall street. A coarse-crystalline marble, known as "snowflake marble," from Pleasantville, in Westchester county, is in the lower part of the walls of the St. Patrick Roman Catholic cathedral, on Fifth avenue, with Lee marble above and Cockeysville, Maryland, marble in the towers. The several kinds appear quite sharply defined in their differences due to exposure in weathering.

These references give proof of the wide variation in the enduring properties of the marbles which have been in general use in the city. Some of the Westchester marbles appear to be as durable as the best sandstones. That there is a gradual decomposition and wear of the surface is evident in the loss of polish on the best marbles, when exposed for many years to the corrosive action of the atmosphere of the city. An objection to some of the marbles in the market is their granular structure, in which the grains fall out on weathering, and the ruin of the stone is only a question of a comparatively short period of time. Marble is apparently again coming into favor in New York, in combination with light-colored brick. The pleasing effect of these materials commends it to the attention of architects and builders.

For the ornamentation of interiors, for wainscoting, tiling, etc., the black marbles from Glens Falls; the white and varigated marbles from Vermont; Tennessee marbles; Mexican onyx; and various colored marbles from France, Belgium, Spain, Italy and Algeria are in common use.

Sandstone

The variation in color, texture and other physical properties among the sandstones, is nearly as wide as their range of occurrence, and they are well represented in New York. Commercial conditions have had much influence, however, in determining the great use of some kinds, and to the ex-

clusion of others of equal, or even superior, quality. The tide of fashion in building, also, has been a powerful factor in creating a demand for certain kinds of sandstone. Architectural considerations and inherent valuable properties appear to have been ignored in the case of sandstones of many localities and quarry districts.

Of all the sandstones used in New York, the Connecticut brownstone has had the longest and most extensive use. The decades 1840 to 1860 witnessed the culmination of the brownstone period. It is so common and well known, that examples need not be here particularly mentioned, save to illustrate some general statements as to its use and value. It has been employed very extensively in trimmings with red brick, in all parts of the city, most largely in thin blocks, set on edge, as a front facing — as it were, a veneer of stone — and more recently, to a lesser extent, in rock-face blocks, in course work, and for fronts. And it is this practice of setting it on edge which has in so many cases occasioned its rapid scaling, and brought it into disrepute with many builders and architects. No other stone has suffered so much in the hands of its friends. A similar treatment of many of our granites, marbles and other sandstones would have developed their inherent weakness and justified like criticism. In spite of defects, due to a laminated structure, in some cases to a loosely aggregated texture, and almost universally faulty position, this sandstone finds a good demand, and its use is not actually decreasing, although, relatively, its sales in the city are said to be less than formerly. Its rich brown color is well suited to cities, inasmuch as it cannot grow dingy-looking nor is it discolored, as the white marbles, the gray granites, and the Dorchester and Ohio sandstones. It is not so glaring to the eye as the latter, nor so dull and hot as red brick. When sawed, the structural figures sometimes are so developed as to look like faint tracery on the surface, and add to its beauty. These even surfaces always keep clean-looking as they have no

lodging slopes whereon dust and dirt can accumulate, as in the case of rock-face blocks. For the fronts of dwelling-houses, which are destined to change or reconstruction before the tide of business, and whose average life rarely equals that of its owner or occupant, brownstone, even on edge, has its advantages and serves its day and purpose. When selected with care, and placed on its bedding planes, it is a durable and beautiful building material. The Vanderbilt houses, on Fifth avenue, between Fifty-first and Fifty-second streets, the Stuart house, at the corner of Sixty-eighth street, and others on the same avenue, above Forty-second street, and many on Madison and Park avenues, and West Fifty-seventh street, show Connecticut brownstone to its best advantage. On the other hand no other variety of stone used in the city appears in so many buildings to be in such a state of disintegration and hastening to ultimate ruin. The rear wall of the Court of General Sessions building, in City Hall park, although dating back to 1852, only, is a sad example of exfoliation on a large scale. In the older cross streets, below Fourteenth, the brownstone sills, caps and stoops of the older private houses are, generally, much disintegrated and out of repair. On the lower part of Fifth avenue, examples are numerous where the fine-tooled blocks are scaling badly. The balustrades, rails and posts are particularly in bad condition, owing to the splitting of the stone which, in these cases, is set vertically. The Brick Presbyterian church, at the corner of Thirty-seventh street, has lost the greater part of the original surface of its stone pilasters by flaking. On West Twenty-third and West Thirty-fourth streets, between Sixth and Eighth avenues, the decay of the brownstone is seen in many houses and in several church fronts.

In some of the newer buildings, up-town and beyond the park, brownstone, in rock-face blocks, and set on bedding plane, is seen. A tendency in this direction is eminently to be desired. The greater durability, when employed in

this way, will doubtless serve to regain favor with all interested in good buildings.

It should be said in this connection, that the Connecticut quarries produce a great variety. Some of these sandstones have a laminated structure, which tends more rapidly to exfoliate than the more homogeneous kinds, and particularly when set on edge in building fronts; some of it is shaly in places and is more liable to disintegration and decay, and does not exhibit so much flaking off, but crumbles to pieces upon long exposure. Much of the Connecticut brownstone, which has been used in the city, is of this inferior kind and low-priced. Some of the newer and cheap contract-built apartment-houses in the up-town streets, are illustrations of the more laminated varieties which are already beginning to show signs of exfoliation. The difference between the well-selected and the more inferior kinds can be seen in the stone of some of the older buildings of the city.

Brown sandstone from the New Jersey quarries is well represented in the city, and notably in several of the more ornate church edifices and private houses. The New Jersey sandstone is more of a reddish-brown and less sombre color than that of Connecticut, finer grained and less micaceous. It is not generally so laminated in structure, and approximates more closely to a "freestone." Trinity church (1846) is a fine architectural example of the stone from Little Falls. The decay in some of the stones of the exterior walls necessitated a careful examination and redressing a few years ago.*

The Newark sandstone is represented in the Temple

* Dr. Thomas Egleston, of the Columbia College School of Mines, made an exhaustive investigation of the causes of the decay of the stone in this building in 1880, and found that there were four leading varieties of stone used in it, and that the stone was not all well selected. He says: "By a careful selection of stones with siliceous binding materials and the rejection of all others, material might have been selected that would have lasted indefinitely."—Cause and Prevention of the Decay of Building Stone, read before the American Society of Civil Engineers, June 24, 1885, Vol. xv, Transactions.

Emanu El, Fifth avenue, a costly Saracenic piece of architecture; in the chaste and elegant gothic pile of the Collegiate Reformed church, Fifth avenue and Forty-eighth street, and in several other large church buildings. The stone in the tower of the Forty-eighth street church is dark-colored through the accumulation of soot and dust. The stone in the Fifth Avenue Presbyterian, also from the Newark quarries, shows the presence of some argillaceous seams and small pockets, which have begun to crumble and have required repairs.

The most popular of the New Jersey sandstone (freestone) come from the Belleville quarries. And some of the dealers report the demand for the finer grade of "liver-rock" of these quarries as steadily in excess of the supply. The more noteworthy buildings in which Belleville stone has been used are mentioned in the list at the end of this section. The stone is generally dressed with fine-tooled or pointed surfaces, but in some of the newer constructions rock-face blocks are used and in regular courses and with the dressed stone for trimming. Several ornate church buildings on Madison avenue show the Belleville stone effectively, and to its advantage, as compared with other brown sandstones, which have been so largely employed, especially in the construction of churches in the upper part of the city.

For domestic architecture these New Jersey sandstones have not been employed to the extent comparable to that of the Connecticut brownstone, and their principal use has been in the construction of public buildings, and not for facings and fronts. Quarry conditions and transportation rates have combined to limit their use in New York.

The Massachusetts red and brown sandstones, quarried near Springfield, in the Connecticut valley, and known in the market as East Longmeadow sandstone, although introduced recently, have become favorites with architects and builders, and have found a large demand. On account of their uniformity in color and the ease with which they are

dressed, they are adapted to carved work, and the pleasing contrast of the tooled surfaces with the red or brown rock-face, suggests this combination, particularly in massive walls and fronts. For trimmings with gray and reddish-gray granites, as the Milford, Massachusetts, granite, these sandstones have been used extensively. The softness of some of these Longmeadow stones makes their working less expensive, and thus, indirectly, creates a demand for them where harder and more durable stone, whose working is attended with more labor and cost, cannot compete. Reference has been made on pages 289–290, to some of the large office buildings, down-town, in which the Longmeadow stone can be seen, and other structures are in the list further on in this section. In the upper part of the city the church of the Holy Trinity, Lenox avenue and One Hundred and Twenty-second street, is a fine architectural example of the sandstone and granite; the Park Presbyterian church, at the corner of Eleventh avenue and Eighty-sixth street, has it, with the Lake Superior red sandstone in the trimmings. For private houses, also, the Longmeadow sandstones have come into favor, and they appear to be taking the place of Connecticut brownstone, here, as well as in the construction of the more massive business and public buildings.

The Longmeadow sandstones also belong, geologically, to the formations of the Triassic age, as do the Connecticut and the New Jersey brown sandstones, which have been noticed above.

Sandstones for building, from New Brunswick and Nova Scotia, have been imported largely, but the importations have fallen off greatly, and the so-called "Nova Scotia stone" has ceased to be a leading variety in this market. They are from the carboniferous formations and are generally light-colored. Their large use has given us numerous buildings in all parts of the city wherein they can be seen. That of the New York Historical Society, Second avenue

and Eleventh street, is a good example of the Dorchester freestone, which shows little sign of decay, after nearly forty years' exposure; the American Exchange National Bank building, Broadway, corner of Cedar street; the Reformed church, on Madison avenue and Fifty-seventh street, and the "Dakota," on West Fifty-seventh street, are other examples.

The bridges and the fence walls of Central park, and much of the stone masonry in the park, are constructed of freestone from Dorchester and Albert, in New Brunswick. There are many house-fronts up-town which have these sandstones either as trimmings with red brick, or as ashlar with the same stone facings. Generally they are olive-colored and fine-grained and soft enough to be worked readily. Hence, they have been used in nearly all cases in the form of dressed dimension blocks, and rarely with rock-face surfaces. They are not "reedy," that is, they are not laminated, and are worked equally well in all directions and are true "freestones." In consequence of this structural nature, flaking is not common. Their softness, as compared with Connecticut brownstone, causes a more rapid disintegration and decay on weathering, and such decay is noticeable, particularly on the southern and south-western exposures, and less on north-facing walls. The fence posts in front of the Protestant Episcopal church on the corner of Fourth avenue and East Forty-second street, and the Church of the Heavenly Rest, near Forty-fifth street, show this disintegration, and roughened, south-west surfaces. Some of the fronts on the upper part of Fifth avenue, and some on Madison avenue, above Thirty-fourth street, show like effects. Perhaps the most pronounced case of decay is to be seen in the carved work of the terrace wall and stairways, at the north end of the Mall and bordering the lake. The fluted posts and ornamental caps have had to be covered during the winter, for their protection. The stone is so much weathered here that it is possible to abrade the surface by the hand.

Some of these "Nova Scotia" sandstones contain small nodules of pyrites, which on oxidation produce stains. Examples are to be seen in East Forty-second street. Discoloration also is seen in some cases.

Ohio Sandstone. — Under this head are here included the light-buff and bluish-gray, fine-grained sandstones, which are quarried in the Waverly group of the sub-carboniferous * formation, in the north-eastern part of the state. The varieties known in the New York market are the Berea, the Amherst and the Euclid sandstones. The Berea sandstone is usually of a darker shade of color and less "reedy" than the Amherst, and is preferred by builders here. The building of the Collegiate Reformed church of Harlem, Lenox avenue and One Hundred and Twenty-third street, is one of the best specimens of the Berea grit.

The "Euclid bluestone" is seen in the new houses of West Seventy-second street and west of the Boulevard. It has been used to some extent in the fronts of the west side, up-town blocks of houses, in juxtaposition, with other sandstones and oolitic limestones. The building on the corner of Barclay and Broadway, erected in 1857 is an example of the Amherst stone.

Dr. Alexis A. Julien says of this stone in his chapter on "The durability of building stone in New York city and vicinity." † "Its rich content of quartz, said to reach ninety-seven per cent, in the buff stone from Amherst, renders this one of the most promising, in regard to durability of all the freestones of the sandstone class yet introduced here. Buildings constructed of this material in this city since 1857, * * * show no decay, but only discoloration. In other instances (e. g., rows of houses on Fiftieth street west of Fifth avenue, on Madison avenue between Thirty-fourth and Forty-third streets, etc.) the blackened discoloration and frequent chippings of edges of the soft stone are quite offensive."

* Report on the Geological Survey of Ohio, Vol. v, p. 578.

† Tenth Census of the United States, Vol. x, p. 369.

Among the sandstones which find a market in New York and from other states are the brown sandstone from Hummelstown, Pennsylvania, the Lake Superior or Portage red sandstone, and the red sandstone from Fort Collins, Colorado. The Fulton National bank building, on Fulton street, is a fine example of the Hummelstown stone. It is of a dark-brown color, fine-grained, hard and apparently durable. The new houses on West Sixtieth street, between Broadway and Ninth avenue show it in the fronts of dwellings.

The Portage red sandstone from the Kewenaw peninsula, Lake Superior, Michigan, is coming forward rapidly as a favorite building stone. Its deep rich color, its homogeneous structure, the ease with which it can be cut and dressed, and the large size of blocks obtainable, commend it. The presence of gray spots and the seamy nature of the inferior stone is against it, when not selected with care. An example is the Manhattan Savings bank building, Broadway and Bleecker street. Although the carriage is by rail, the low rates allow of its sale in New York at prices which make it a keen competitor with other sandstones in this market, and give promise of an extensive use.

Scotch Sandstones.—The sandstones, which are imported largely as ballast, from Scotland, are from the New Red sandstone formation; and from Corsehill, near Annan, Dumfriesshire; from Gatelaw bridge, in the same county; and from the Carboniferous formation at Ballochmile, in Forfarshire. They are sometimes known as Carlisle sandstone, from Carlisle, the shipping port. The Corsehill stone is usually of a bright-red color, almost pink in some cases, even-grained and homogeneous in structure. It is seen in the Consolidated Stock Exchange building, Broadway, corner of Exchange place; in the Gallatin National bank, Wall street; in the World building, Park Row; and in the Murray Hill hotel. The warm color of the fine-tooled surfaces produces a pleasant effect, but its durability in our climate remains to be proven by longer exposure than it has

had in these newer structures. The Gatelaw bridge quarries, north of Corsehill, yield a sandstone which is brownish-red in color, coarser-grained and more siliceous, and apparently more durable than the latter stone. Both districts are represented in the Presbyterian hospital buildings, on East Seventieth street. The Gatelaw bridge stone is to be seen in the bank building on the corner of Forty-second street, at Fifth avenue; also, in St. George's church, East Sixteenth street.

Although sandstones have been so largely employed in all kinds of building, in New York, yet the greater part has come from quarries and quarry districts outside of the state. The latter have found better markets in the smaller cities near them than in the metropolis. Sandstones from distant parts of the country, and from other states, have been carried through the quarry belts of western and central New York, and have, to some extent, excluded the productions of our state. The commercial relations and varied tastes of the people, as well as the tide of fashion in stone, have produced this effect. It is not due to the superior character and value of foreign and extra-limital sandstone. In consequence of this relatively small demand for state sandstones, there are few prominent buildings to which reference can be made. The Potsdam sandstone is in the new Columbia college buildings; the Albion sandstone appears in the "Guernsey," Nos. 160–164 Broadway, and in the house, north-west corner of Madison avenue and Sixty-eighth street; Medina sandstone (gray variety) in the Calvary Baptist church, West Fifty-seventh street; Portage and Oxford sandstones in Aldrich court, No. 45 Broadway; Warsaw blue sandstone in the building Sixth avenue and West Thirty-fourth street; and Hudson river blue-stone in the Tiffany house, Madison avenue and Seventy-second street. All of these references are to comparatively new buildings, and they do not afford any positive evidence of the enduring value of these sandstones in New York.

The red sandstone from Haverstraw was used formerly in the city. It has disappeared from the market.

A difficulty in the way of the easy introduction, and the more general employment of the harder sandstones, as the Potsdam and Oxford blue sandstone, is the greater expense of dressing them. The softer Warsaw and Portage stones have found a more ready market for facings, mainly.

The Hudson river blue-stone, included here under sandstones, from the Hudson and Delaware valleys, is an exception to the general statements about New York sandstones above; and its use in constructive work continues large, although the greater volume of that stone is laid in street sidewalks and curbing. For lintels, sills, caps, water-tables, platforms and steps the blue-stone has no superior, for tensile strength and durability, and there is a steady demand for it.

Limestone

Limestones from New York state quarries have been employed for heavy masonry, as, for example, in the anchorages and approaches of the New York and Brooklyn bridge, where the blue limestones of Lake Champlain and some of the Rondout quarries were used. The Sandy Hill quarries furnished stone for the Croton aqueduct gate-house, and the sea wall on Governor's Island, These limestones answer well for such construction. The massive Lenox library building, Fifth avenue and Seventieth street, is of Lockport gray limestone. Of a light-gray color, it looks when hammer-dressed, like a granite, but on close inspection the exterior appears to be worn and pitted by the falling out of the fossiliferous portions, and the tool-marks are already nearly effaced by the wear of the surface. These signs of wear are more apparent on the south than on the north fronts. This decay of a beautiful stone, when protected from the weather, is said to be due to the placing it on edge.

The oolitic limestones of Indiana and Kentucky, intro-

duced within a decade of years, have already acquired a wide use for buildings of all kinds. And they are to be found in all parts of the city. They are known under various names, from the quarry localities, but in general all of the varieties are included under the head of Indiana limestones. The Bedford quarries, in Lawrence county, have a buff-colored stone at the surface, underlain by a blue variety, which is harder, more durable in general, and of a superior quality. The variety is specified in building contracts in the city. The stone is of a pleasing shade of color, fine-grained, even in texture and easily carved. It can be seen in the New York Times building, Park Row, and in the elegant and ornate house of William K. Vanderbilt, Fifth avenue and Fifty-second street ; also, as a trimming with red brick, in Cornelius Vanderbilt's house, at Fifty-seventh street and Fifth avenue, and in Cyrus Clark's house, corner of West Ninetieth street and Riverside avenue. The fine-tooled and carved work of the house at Fifty-second street and Fifth avenue shows how well it receives ornamentation, but the discolored stone of parts of the front which are less exposed, detract from its beauty.

The new building at the south-west corner of Wall and Nassau streets already looks muddy, and the spalls, from the edges of the course-work, indicate weakness. Some of the discoloration of the Indiana limestones has been attributed to the exudation of oil.*

The stone from the quarries of Elletsville, Monroe county, is noted in the front of Smith building, Cortlandt street. It is not so markedly oolitic as the Bedford stone. In the New York Cotton Exchange, on Beaver street, the front is disfigured by the stains or discolorations in the stone. It is reported to be an inferior quality of Indiana stone.

The newer blocks of houses up-town, above Seventy-second street, contain many costly examples of the Indiana limestone. West Seventy-second, Eighty-first and Ninety-

* Dr. Alexis A. Julien, U. S. Tenth Census, Vol. x, p. 369.

first streets, West End avenue, St. Nicholas avenue, Convent avenue and Lenox avenue have many such buildings.

The large size of the blocks which these quarries yield; the homogeneous texture and composition; the softness of the stone and its fitness for carved work; and low freight rates, making prices competitive with eastern stones, have all tended to a greatly increased use of the Indiana oolitic limestones. Their durability in New York remains to be proven by longer periods of exposure to the action of the atmosphere than they have as yet had.

Caen stone, a light-colored, soft, oolitic limestone, from Normandy, France, has been used in New York city for interior decorative work, and in exterior walls. In Trinity chapel, Dr. Egleston reports, that "the stone is a little clouded with dirt, but otherwise is apparently as sound as the day it was erected."* Where put in outside walls it has failed to resist decomposition and decay, and has very generally been replaced by other stone. An example of the active disintegration of this stone may be seen in the trimmings of All Souls' Unitarian church and parsonage, corner of Fourth avenue and East Twentieth street. The water-tables particularly are in bad condition.

Slate

Slate is so rarely seen in the composition of exteriors in New York city, excepting for roofing, that it is hardly admissible in the list of building stone. For interiors, as wainscoting, floors, tiling, etc., it is used largely. Sawed slate lintels, sills and steps have been put in some private houses and other smaller structures, but a comparatively small amount of stone has been used in this way. For pitch-roofs slate has been in fashion for many years and has proved to be a superior roofing material. It is put on the larger, business and public buildings generally; very

*The Cause and Prevention of Decay of the Building Stone, p. 28.

little is laid on private dwelling-houses in the more compactly-built districts of the city. The blue-black slates of the Bangor and Slatington regions of Northampton and Lehigh counties in Pennsylvania; the green and the variegated red and green, and the purple slates of Vermont; and, the red, green and purple slates of Washington county, are the leading varieties in this market. The red slate of Washington county is much esteemed, commanding high prices, and is employed in the more costly buildings, as a more ornamental roofing material. All of the red slate in the city is from these slate quarries of the state. A little of the black slate comes from Maine and some from Maryland, and the Peach Bottom slate district of Pennsylvania.

Street Pavements

Sidewalks.— The older stone sidewalks of the city are laid with gneiss or mica slate. Much of the former was probably from Haddam, and the latter from Bolton, Connecticut.* Few such walks are now to be seen.

The Hudson river blue-stone is the leading variety in use, both for curbing and for paving the walks. It is brought from the quarries of Ulster, Sullivan, Orange and Delaware counties, and from the blue-stone territory of Pennsylvania, near the Delaware river, and adjacent to New York. In the older walks the flag-stones are small and thin and with natural faces derived by splitting. The demand for better work and stone to resist more and heavier wear has called for much thicker flag-stones and of larger size, and true surfaces, such as are given by planing. In many cases the length of the stone is equal to the width of the walk so that it consists of a single line of large dimension flags. Examples of such stone are to be seen in front of the Vanderbilt houses on Fifth avenue; on the lower part of Broadway, in Wall street, in front of the large office buildings, and generally before larger and newer structures.

* Dr. Alexis A. Julien, Tenth Census of United States, Vol. x, p. 327.

There is an increasing use of large, hewn blocks of granite for the sidewalks and for cross-walks. They are strong and hence are not so liable to be broken by heavy traffic, but the projecting points of the surface are soon worn quite smooth and slippery, when wet, and the little inequalities are apt to hold water and stay wet longer than the blue-stone, whose uniform wear results in an even surface which retains a gritty texture and is not slippery.*

In the more recently paved streets up-town, there is a noticeable use of artificial stone, especially in front of private houses. For curbing, granite and blue-stone are used almost exclusively.

Pavements.— The roadways of the streets are paved with cobble-stones, stone blocks, macadam and asphalt. Cobbles and small boulders, obtained from the drift formations, were formerly in use almost exclusively. In many of the older-paved streets, particularly on the east side and down town, trap-rock is seen. Granite block is taking the place of both the Belgian block and specification trap pavement. The Russ pavement has all been taken up. The following statistics show the areas and lengths of the several kinds of pavement for the date June 30, 1890.†

KIND OF PAVEMENT.	Square Yards.	Lineal Feet.	Miles.
Specification granite	2,225,810.75	529,107.73	100.21
Block granite	673,402.	136,717.	25.89
Specification trap	1,248,528.82	355,821.90	67.39
Belgian block	3,045,214.04	695,290.60	131.68
Cobble	101,642.76	27,174.60	5.13
Asphalt	71,190.43	17,692.	3.36
Wood	516.	158,	.03
Russ	2,964.	621.	.12
Macadam	908,354.	133,748.90	25.34
	8,277,622.80	1,896,331.63	359.15

* All stones like the granites, which are capable of receiving a polish, are inferior to the sandstones for sidewalks; wear polishes the former.

† From F. C. Fox, superintendent of streets, department of public works.

Examples of Stone Construction in New York City

Granite — Maine

Locality	Structure	Date
Blue Hill, Hancock county.	U. S. Barge office, Battery....	
Spruce Head, near Rockland.	Part of towers, New York & Brooklyn bridge; bridges of 4th avenue improvement.......	
Red Beach, Washington county.	Columns in front of World building, Park Row.	
Hurricane Island.	Part of towers, New York & Brooklyn bridge; part of New York post-office..............	
Fox Island.	Part of towers, New York & Brooklyn bridge; basement of Stock Exchange; Merchants and Manhattan National Banking Co., Wall st., mullions of windows (first story of Conn. granite); Methodist Book Concern building; 5th ave., cor. 20th st......................	
Deer Island.	N. Y. C. & H. R. R. grain elevators..........	
Vinal Haven, in Penobscot bay.	Part of Washington bridge, Harlem river....	
St. George.	Pedestal Lafayette monument, Union square.	
Augusta.	Mills building, cor. Broad st. and Exchange place.....................................	
Biddeford.	Docks along North river........	
Hallowell, Kennebec county.	Tribune building, in part; Ludlow street jail; "Tombs," in Center street; Standard Oil Co.'s building, No. 26 Broadway; Union Trust Co.'s building, No. 69 Broadway.....	1840
Round Pond	Seventh regiment armory....................	
Frankfort, Waldo county.	Parapets of Washington bridge, Harlem river.	
Jonesboro.	Hunnewell building; front of Welles building, cor. of Broadway and Beaver st	
Mt. Desert Island.	Metropolitan Museum of Art; Fort Schuyler..	
Dix Island, Knox county.	New York post-office; first base course of St. Patrick's cathedral; Court-house, City Hall park; part of the Staats-Zeitung building (first story); fortifications in harbor; marine docks at Castle Garden; and retaining-walls of barge-office and basin......... ...	
Maine granite (in general).	Times building (first and second stories) Park Row; house, north-east cor. 5th ave. and 66th st. (rock-face ashlar with polished facings); house, cor. 5th ave. and 78th st. (alternating courses of polished and rock-face blocks)................	

New Hampshire

Locality	Structure	Date
Concord.	Booth's theatre, 6th ave. cor. 23d st.; Germania Savings Bank, south-east cor. 14th st. and 4th ave. (basement of Quincy granite); part of towers and approaches New York and Brooklyn bridge; basement and trimmings of three stories of Tribune building; Equitable Assurance Co. building, Broadway.	

Massachusetts

Locality	Structure	Date
Quincy.	Astor house; U. S. Custom-house; Staats-Zeitung building (in part); Germania Savings Bank, cor. 14th st. and 4th ave. (basement) .... World building, Park Row (basement)......	
Cape Ann.	The dark base stone and spandrel-stones of the towers and approaches of the New York and Brooklyn bridge.........	
Milford.	No. 71 Wall st.; U. S. Trust Co., No 45 Wall st.; Lutheran church, cor. Madison ave. and 73d st.; Church of the Holy Trinity, Lenox ave. and 122d st.	

Rhode Island

Locality	Structure	Date
Westerly.	New York Mutual L. Ins. Co. building, Nassau, cor. Cedar st. (first story); upper stories of Merchants & Manhattan National Banking Co., Wall st.; Red granite, Demarest building, north-east cor. 5th ave. and 33d st.	

Connecticut

Locality	Structure	Date
Leetes Island, New Haven county.	Washington bridge (in part), Harlem river...	
Niantic, New London county.	Reservoir in Central park..................	
Stony Creek, Branford, New Haven county.	Central R. R. Co. of New Jersey office building, Liberty st............	
Connecticut granite (general).	Judge building, 5th ave. cor. of 16th st.; St. Andrew's P. E. church, cor. 5th ave. and 127th st....	

New York.

Locality	Structure	Date
Ramapo, Rockland county.	Washington bridge, in part Harlem river.....	
Breakneck mountain quarry, near Cold Spring, Putnam co.	Part of High bridge, Harlem river	

New Brunswick

Locality	Structnre	Date
St. George's.	American Museum of Nat. History extension, 8th ave. and 77th st.; columns of the Stock Exchange building, Broad st	

Gneiss

New York

Locality	Structure	Date
Manhattan island and Westchester co.	Side walls of St. Paul's church, Broadway and Fulton st.; St. Matthew's Lutheran church, Broome, cor. of Elizabeth sts.; Asbury M. E. church, Washington square; church, cor. Madison ave. and 38th st.; St. Paul's Evangelical church, W. 34th st. near 7th avenue; Croton reservoir, 42d st. and 5th ave.; Church of the Paulist Fathers, 9th ave. and 59th st. (facings of Connecticut granite); American Express Co.'s building, Madison ave. cor. 47th st.; All Souls' P. E. church, Madison ave. cor. of E. 66th st. (with brownstone trimmings); house, Riverside ave. cor. of W. 104th st.; Croton reservoir, Central park; N. Y. Juvenile Asylum, W. 178th st. near 10th ave.; St. John's College buildings, Fordham (with Tremont marble trimmings).	1764–6 1841

Marble

Vermont

Locality	Structure	Date
Manchester.	Drexel & Morgan building, cor. of Wall and Broad sts.; Collegiate Reformed church, 5th ave. cor. of 29th st.................... ...	1854
Sutherland Falls.	Sutherland building, S. E. cor. 63d st. and Madison ave................................	
Winooski.	Reredos, Grace church, Broadway, cor. 10th st.; National Shoe and Leather bank, Broadway, cor. Chambers st....................	

Massachusetts

Locality	Structure	Date
Lee.	St. Patrick's cathedral, 5th ave. and 50th st., upper part of building (towers of Cockeysville, Md., marble)........................	1858–79
West Stockbridge.	City hall; U. S. Treasury building, Wall st. ..	
Sheffield.	South walls of wings of County court-house, City Hall park..........................	

16

New York

Locality	Structure	Date
Tremont.	St. John's College, Fordham (trimmings)......	
Tuckahoe.	St. Patrick's cathedral; National Bank of Commerce building, Nassau st.; Stock Exchange building, Broad st.; U. S. Assay office, Wall st.; Brown Bros. building, Wall st.; Stewart building, Broadway, Chambers and Reade sts.; part of County court-house (Corinthian columns); Stewart house, 5th ave. cor. of 34th st.; Hotel Imperial, Broadway, cor. of 32d st.; block, east side of 5th ave., 57th–58th sts........................	1823
Pleasantville, Westchester county.	St. Patrick's cathedral, to top of tracery of windows; Union Dime Savings bank, 32d st. and 6th ave.; Orient Mutual building, Nos. 41–43 Wall st............................	
Hastings, Westchester county.	University building on Washington square...	
Westchester county. (In general.)	U. S. Hotel, Fulton and Pearl sts.; M. E. church, 4th ave. and 21st st.; National Academy of Design, 23d st. cor. 4th ave.; Fifth Avenue hotel, 5th ave. and 23d st., N. Y. Herald building, Broadway, cor. Ann st.; National Park Bank building, Broadway, cor. of Fulton st.; Grace church, Broadway and 10th st.; Grand Opera House, N. W. cor. 8th ave. and 23d st..............	1845

Serpentine

	Trimmings of Beth El Synagogue, S. E. cor. Lexington ave, and 63d st.; trimmings of St. Bartholomew's P. E. church, Madison ave. cor. E. 44th st.	

Sandstone

New Brunswick

Mary's Point, Albert.	Reformed church, 57th st. and Madison ave.; fence surrounding Central park; bridges and most of freestone masonry in the park.	
Dorchester.	N. Y. Historical Society building, 2d ave. and 11th st.; part of wall and bridges in Central park; Continental National bank, Nassau st. opp. U. S. Treasury; Temple court, cor. of Nassau and Beekman sts.; Coal and Iron Exchange, Cortlandt st.; Merchants' Exchange Bank building, Broadway; Berkeley house, 5th ave. cor. 9th st.; Victoria hotel,	1857

Locality	Structure	Date
	5th ave. cor. 27th st.; Astor houses, 5th ave. N. W. cor. 33d st.; house S. E. cor. 5th ave. and 73d st.; house, Madison ave., east side, cor. 40th st.; Church of Heavenly Rest, Madison ave. and 42d st.; part of the "Dakota," W. 72d st.	
	NOVA SCOTIA	
	American Exchange Bank building, Broadway, cor. Cedar st.; Hotel Bristol, cor. 5th ave. and 42d st.	
	MASSACHUSETTS	
East Longmeadow.	United Bank building, Broadway, cor. Wall st.; U. S. Trust Co. building, No. 45 Wall st. (trimmings); Chatham National bank building, N. E. cor. Broadway and John st.; Union League Club house, 5th ave. cor. 39th st.; the "Osborne," 57th st. and 7th ave.; church, S. W. cor. Madison ave. and 73d st.; trimmings of Church of the Holy Trinity, Lenox ave. and 122d st.; St. George's P. E. church parish building, E. 16th st.; Park Pres. church, 10th ave. cor 86th st. (rock-face ashlar, with trimmings of red Portage, L. S, sandstone). New York Acad. of Med., west 43d st..	
	CONNECTICUT	
Portland.	Commercial National Bank building, N. E. cor. Wall and Pearl sts.; Insurance building, S. W. cor. Wall and William sts.; Court of General Sessions building, Chambers st.; Broadway Bank building, Broadway, cor. Park place; Vanderbilt houses, 5th ave. 51st–52d sts.; house, N. E. cor. 5th ave. and 67th st.; Mrs. R. L. Stuart's house, N. E. cor. 5th ave. and 68th st.; houses, Madison ave., east side, 37th–38th sts.; houses, Park ave. cor. 36th st.; houses, 8th ave. bet. 84th and 85th sts..	1852
	NEW JERSEY	
Little Falls.	Trinity church, Broadway, 1846; Mt. Morris Bank building, 4th ave. cor. 124th st.......	
Newark.	Collegiate Reformed church, 5th ave. cor. 48th st.; St. Thomas' church, 5th ave. cor. 53d st.; Fifth Avenue Presbyterian church, cor. 55th st.; Reformed P. E. church, Madison ave. cor. 55th st.; Trinity chapel, W. 25th st.; Temple Emanu-El, 5th ave. and 43d st......	1872
Belleville.	Trinity church parish building, New Church st.; Mills building, cor. Broad st. and Exchange place; "Tower building" No. 50	

Locality	Structure	Date
	Broadway; Schermerhorn building; Field building, Broadway; house, 5th ave. and 93d st.; house, Madison ave. and 28th st.; Villard house, Madison ave. cor. 50th st.; Manhattan Athletic Assoc. building, Madison ave., 44th-45th sts.; Madison ave. M. E. church, Madison ave. and 60th st.; Baptist Church of Epiphany, Madison ave. cor. 64th st.; Church of the Messiah, cor. Park ave. and 34th st.; house, N. E. cor. West End ave. and 75th st. (trimmings); Cancer hospital, 8th ave. bet. 106th and 107th sts..........	
	PENNSYLVANIA	
Hummelstown.	Fulton National Bank building, Fulton st. cor. Gold st.; Pottier, Stymus & Co.'s building, 5th ave. bet. 41st and 42d sts.; houses, W. 60th st. bet. Broadway and 9th ave.........	
	OHIO	
Amherst.	Building cor. Broadway and Barclay st.......	1857
Berea.	Building, cor. Fulton and Cliff sts.; Collegiate Reformed church, Lenox ave. and 123d st.; Calvary Baptist church, W. 57th st. (trimmings); chapel, 7th ave. and 128th st.......	
Euclid.	Houses, W. 72d st. west of Boulevard....	
	LAKE SUPERIOR	
Portage, Michigan.	Trimmings of upper stories of the Armory building, cor. Whitehall and Pearl sts.; Manhattan Savings Bank building, Broadway, N. E. cor. Bleecker st.; trimmings of Park Pres. church, 10th ave. and 86th st.	
	VIRGINIA	
Potomac.	Red sandstone. House, west 57th st., near and west of 6th av.	
	COLORADO	
Fort Collins.	House, E. 71st st. near 5th ave...............	
	SCOTLAND	
Corsehill near Annan, Dumfries.	Consolidated Stock Exchange building, Broadway and Exchange place; Gallatin National Bank building; building, Nos. 8-12 Wall st.; Manhattan Trust Co. building, Wall st. near Broadway; Northern Assurance Co. building, cor. Pine and William sts.; Astor building, Nos. 7-9 Pine st.; World building, Park row; Telephone Exchange building, Cortlandt st.; Murray Hill hotel, Park ave. and 41st st. (basement of granite).............	

Locality	Structure	Date
Gatelaw bridge, Dumfriesshire.	Bank building, S. E. cor. 5th ave. and 42d st.; houses, west side Madison ave. above 38th st. (trimmings with red brick); St. George's P. E. church, 16th st. cor. Stuyvesant sq.; Bliss block, 6th ave. and 118th st.; houses, 73d st. near West End ave.; houses, 124th st. bet. 6th and 7th aves.............. ...	
Ballochmile, Forfarshire.	Houses in W. 78th st.; house, 57th st. and 7th ave....................................	
New York		
Potsdam, St. Lawrence county.	Columbia college buildings (basement, string-courses, facings); Rutgers Riverside Pres. church, W. 73d st. (with facings of Connecticut brown-stone)............	
Albion, Orleans co.	Guernsey building, Nos. 160–164 Broadway; house north-west cor. Madison ave. & 68th st.	
Medina, Orleans co.	Calvary Baptist church (gray Medina sandstond in ashlar work, trimmings of Berea sandstone), W. 57th st. near 6th ave........	
Warsaw, Wyoming county.	Public school building (trimmings), St. Nicholas ave. and 156th st.; part of building north-east cor. 6th ave. and 34th st.; houses (trimmings), West End ave, bet. 89th and 90th sts.	
Portage, Livingston county.	Aldrich court, 45 Broadway (trimmings); porch of house, 5th ave. and 77th st	
Oxford, Chenango county.	Aldrich court, No. 45 Broadway (walls only); basement of house, south-east cor. of Boulevard and W. 90th sts........................	
Hudson River blue-stone.	Tiffany houses, Madison ave. cor. 72d st.; part of building north-east cor. 6th ave. & 34th st.	
Haverstraw (?)	Prot. Epis. Church of the Ascension, 5th ave. cor. 10th st.; St. Stephen's R. C. church, 28th st.; house of Mrs. Cruger, 14th st.; house of D. Willis James, Park ave. and E. 39th st..................................	

Limestone

New York

Locality	Structure	Date
Kingston, Ulster co.	Part of anchorages, approaches and base of towers of New York and Brooklyn bridge..	
Sandy Hill, Washing county.	Croton aqueduct gate-house; walls of Harlem railroad improvement; sea-wall on Governor's Island...........................	
Willsborough, Essex county.	Piers of New York and Brooklyn bridge	
Lockport, Niagara county.	Lenox Library, 5th ave. between 70th and 71st sts.; part of Pres. Hospital (facings), Madison ave. and 70th st	1870–7

Indiana

Locality	Structure	Date
Bedford, Lawrence county.	Building S. W. cor. Wall and Nassau sts.; N. Y. Times building, Park row (above 2d floor); Wm. K. Vanderbilt's house, 5th ave. cor. 52d st.; house of Cornelius Vanderbilt, N. W. cor. 5th ave. and 57th st. (with red brick walls); Appleby building, W. 58th st.; building, N. W. cor. 5th ave. and 14th st., Union Square; house, S. E. cor. Boulevard and 90th st.	
Ellettsville, Monroe county.	Smith's building, Cortlandt st.; Public School building (trimmings), Lenox ave. and 134th st. (first story of Portage sandstone); house, N. W. cor 5th ave. and 115th st.	
Stinesville, Monroe county.	Hotel, cor. Madison ave. and 30th st.; apartment house, 8th ave. bet. 74th and 75th sts.; N. Y. Mutual Life Insurance building, Nassau and Cedar sts. (granite in first story)....	

Kentucky

Locality	Structure	Date
Bowling Green.	N. Y. Cotton Exchange building, Beaver st. cor. Bowling Green; houses, north side of W. 72d st., west of West End ave.; Bloomingdale Reformed church, cor. Broadway and 68th st.	

Indiana

Locality	Structure	Date
(In general.)	Farmers' Loan and Trust Co.s' building, cor. Beaver and William sts.; Bank of America (1st and 2d stories of granite) Wall st.; Mechanics' bank (above 2d story), Wall st.; Demarest building, N. E. cor. of 5th ave. and 33d st.; St. Andrew's M. E. church, cor, 76th st. and Columbus ave.; Harlem Opera house, 125th st.; house, S. E. cor. of Lenox ave. and 118th st.; apartment house, S. W. cor. Lexington ave. and 34th st.; house, N. E. cor. Convent ave. and 144th st.; house, W. 150th st., N. E. cor. of St. Nicholas ave.; St. Francis Xavier college building, W. 16th st.; Central Park apartment houses, 7th ave. and 59th st.; All Angels' P. E. church, West End ave., cor. 81st st.....	

Ireland

Locality	Structure	Date
Ballinasloe, county Galway.	Kelly building, Temple court, Nassau st.......	

France

Locality	Structure	Date
Caen, Normandy.	Interior of Trinity chapel, W. 25th st.; reredos, Trinity church; All Souls' Unit. church, S. E. cor. 4th ave. and E. 20th st.	

Brooklyn

The use of stone in building in Brooklyn is relatively less than in the metropolis. The same general statements, descriptive of the use of building stone in New York, with some slight modifications, are applicable to the city of Brooklyn, which is practically a part of the great metropolis.

There are relatively fewer large mercantile structures and public buildings, and more dwelling-houses, and a notable absence of the large apartment-houses, so common in New York. The number of dwellings in proportion to the population is greater, but in average size and cost they are inferior, and to that extent more generally of brick, and stone fronts are not as numerous and common as in the metropolis.

The Connecticut brownstone predominates in the fronts of stores and dwelling-houses, and in the older constructions. As in New York city, so here, there is an increasing use of other stone, and especially of the oolitic limestones of Indiana and Kentucky.

Among the more important edifices in which stone has been used extensively, the following are given as examples of the several varieties. The list is incomplete, and is presented as an appendix to the more full one of New York, and as a part of the metropolitan district. The United States Government building and Post-office are of granite — Maine. Quincy granite is noted in the memorial arch Prospect Park plaza. The city hall, Kings county court-house and the municipal building are of white marble. The city hall is older and the Westchester county marble in it has weathered to a light-gray color. The newer fronts of the other buildings appear still fresh and white. Trinity Protestant Episcopal church, Clinton and Montague streets, is a beautiful Gothic structure in red sandstone, from the quarries at Middletown, Connecticut. The blocks are fine-pointed ashlar work, in places disfigured by calcareous deposits from the mortar of

the joints. St. Ann's Protestant Episcopal church, Clinton and Livingston streets, is of red sandstone, from New Jersey quarries, with trimmings of Ohio sandstone. In the Academy of Music, on Montague street, the Dorchester sandstone was used freely in trimming, with red brick walls. The Church of the Pilgrims, north-east corner of Remsen and Henry streets is built of gneiss, of which many of the stones are on edge, and in broken courses, and show some signs of disintegration. The Dime Savings bank front, on Court street, is a fine example of the oolitic limestone from Bowling Green, Kentucky. The trimmings are of polished granite. The hall of records, Fulton street and Boerum place, and the new First Reformed church, Seventh avenue and Carroll place, are also of the oolitic stone from Indiana quarries. The Williamsburg Savings bank is a massive building, with Berea sandstone front. The Massachusetts sandstone is noted in the fronts of the large "Berkeley" and "Grosvenor" apartment-houses, in Montague street. In the "Arlington," also in Montague street, a light gray sandstone was used in the first story of the front.

Scotch sandstone, from the Gatelaw bridge quarries, was used in the houses of Stewart L. Woodford, President street, and Herman Behr, Henry and Pierrepont streets, and in the Germania club-house.

Street Work.—For paving cobble stone has been used most largely. Trap-rock also, has had an extensive use. Granite blocks are now in favor and are displacing the older cobbles and Belgian blocks. The total lengths of the several kinds of pavements, are as follows:*

Cobblestone	280 38-100	miles
Belgian block	22 41-100	"
Granite block	55 30-100	"
Asphalt	8 82-100	"
	366 91-100	miles

* From Van Brunt Bergen, First Assistant Engineer, Department of City Works, Brooklyn.

Yonkers

Although a large amount of stone has been used in the city, in constructive works, there are comparatively few all stone buildings. The notable structures are: St. John's Protestant Episcopal church and rectory, built of Westchester gneiss, rock-face blocks; the Roman Catholic church, in course of erection, of sandstone from Belleville, New Jersey, with facings of Carlisle sandstone; the First Methodist Episcopal church, of sandstone; the Baptist church of Connecticut brownstone; the Westminster Presbyterian church, of Westchester county gneiss; and the historic city hall, dating 1682 (front built in 1745), of stone laid in rubble-work, and with brick side-walls. There is one block of dwelling-houses in which the fronts are of Connecticut sandstone. The business buildings are generally of red brick, with stone trimmings.

The boulders of the drift, found in excavating for cellars, and in street grading, which are of diabase from the Palisade range, on the opposite side of the river, yield a durable stone for retaining-walls and foundation work. Some stone is obtained from ledges of gneissic rock cut in the city, but it is inconsiderable in amount, as compared with what is got out of the drift. For trimming, with brick, Hudson river blue-stone and Connecticut brownstone are most largely in favor.

The streets are macadamized roadways, made with trap-rock. Hudson river blue-stone is used for gutter-stone, curbing and for flagging.

Newburgh

Newburgh, from its situation on the Hudson, has had the advantage of low rates of freight, and building stone from various points in the Hudson valley and more distant localities, has been used more or less extensively. For foundations and retaining-walls the blue limestones near the city,

have furnished much stone. Sandstone from Nyack and Haverstraw, and Connecticut brownstone also were much used formerly.

"Washington's Headquarters," built in 1750, is the oldest stone building in the city. The walls are laid up with common field stone, mostly sandstones. Scarcely any signs of weathering are noticeable in them. The St. George Protestant Episcopal church is another old structure, of dressed blue limestone with brownstone sills and water-tables. The limestone has faded and is a gray-white in color, but has not apparently lost in strength or durability. St. Patrick's Roman Catholic church is another structure of limestone, part of which is reported to have come from Kingston quarries. Some of the blocks are weathered yellow, and in some the clay seams appear prominent, although the building is of comparatively recent date. The First Presbyterian church is a large and ornate edifice of a dark, slate-colored sandstone, obtained from near Kingston. The walls are of small stone, laid in broken courses and trimmed with Ohio sandstone. There are no signs of disintegration in the wall stones. Of the buildings in part of stone, the more notable are the Academy of Music (1887) and the Newburgh academy, both of red brick and Massachusetts red sandstone. Connecticut brownstone is seen in the United States hotel, the post-office, and in many cases as door-steps and house-trimmings. Ohio sandstone examples are: the Newburgh city library and the savings bank buildings.

Streets.—The sidewalks are paved generally with bluestone from the Hudson river valley. The aggregate length of paved sidewalks is about thirty miles. Cross-walks and curbing also are of blue-stone.

The roadways are laid with stone to the following extent:*

Cobblestone pavement, two miles; granite-block pavement, four hundred feet.

---

* Statistics of street work from Charles Caldwell, of Caldwell & Garrison, civil engineers, Newburgh.

Poughkeepsie

Hudson river brick predominates as building material in the business part of the city. It is used for the walls, with water-tables, caps, sills and lintels of stone. The foundations are generally of common grades of limestone, sandstone and gneissic rock, which are from small local quarries, or are obtained at points on the river, a few miles away. For trimming brick buildings, Connecticut brownstone has been used largely. Mill street has many residences of brick trimmed with stone. Hudson river blue-stone also has been used extensively, and particularly in the more plain and and less expensive structures. In the Vassar Brothers' Institute of Science, in the Vassar Home and in the Vassar hospital granite trimmings are seen, with red brick walls. Ohio sandstone and red brick are in the city library and in the Baptist church. The more prominent examples of Connecticut brownstone are: First Reformed church, on Main street, basement; Second Reformed church, on Mill street, trimmings and basement; and, the First Methodist Episcopal church, corner of Mill and Washington streets, trimmings only. The notable buildings of stone are: Church of the Holy Comforter, on Main street, of Hudson river sandstone, dressed, and in broken courses, with sills and water-tables of Connecticut brownstone; Christ Protestant Episcopal church and school, corner of Academy and Barclay streets, a large and recently completed structure of Massachusetts red sandstone; St. Paul's Protestant Episcopal church, corner of Mansion and North Hamilton streets, of rock-face gneiss, in broken courses, and with brownstone trimmings. White marble has been used in one front on Main street. Ohio sandstone appears in two fronts of business buildings on the same street. All of the above-mentioned examples in stone construction are comparatively new. One of the oldest stone buildings is on the corner of Main and White streets, and is known as "Duke's

hotel." It is built of the rough stone quarried in the vicinity. The brownstone shows signs of exfoliation in some of the older buildings, but not to the serious extent noticeable in other cities. During the past season it has been discolored in shady locations by the growth of the green algae, known specifically as *ceratodon purpureus*. The excessive amount of moisture seems to have favored its growth, and it was particularly luxuriant on the more shaded walls of Massachusetts sandstone in Christ church.

Streets.— Hudson river flagstone is employed generally in sidewalk and curbstone construction on the principal streets. Brick sidewalks are, however, common, owing to their cheapness. For the roadways, cobble stone pavement has an aggregate length of four and one-quarter miles. Belgian blocks are laid on Market street a length of about five hundred feet, the single example of block pavement in the city.

Kingston

The city of Kingston includes Rondout, with Kingston proper. In the former, brick is the principal building material in the central and business parts of the place; in the latter there are many old, stone houses, dating back to the eighteenth century, besides newer buildings of stone. Hudson river blue-stone is used almost exclusively in brick buildings for sills, lintels, caps, steps and trimmings generally. And little stone from outside the Hudson river district has found its way into construction in Kingston. The best specimen of architecture in stone is the First Reformed church, a massively built structure, and yet of graceful proportions — of blue-stone, from quarries at Stony Hollow and Bristol Hill, four miles north of the city. The stone is slate-colored and of uniform shade, and in thin courses generally. The walls are laid with dressed blocks, in broken courses, with trimmings of the same stone. This church

structure is a fine specimen of the beauty, durability and general excellence of Hudson river blue-stone in walls, for which it has not been employed as largely as other stone, on account of its greater value for flagging. The Second Reformed church, built in 1850, is of limestone from local quarries. It is disfigured by the unequal weathering and consequent variation in color of the calcareous and argillaceous or clayey portions of the limestone. This weathering has not, however, as yet, impaired the strength or affected seriously the enduring quality of the stone. The Ulster County court house, built in 1818, is of blue limestone and the good condition of the walls shows the durability of the stone. The number of old stone houses in Kingston is a unique fact, in our American towns. General George H. Sharpe, in a lecture on the "Old Houses of Kingston," refers to eighty-five stone buildings; according to a recent revision of the list,* there are now fifty-eight standing and occupied; the best known, and probably the oldest, is the "Senate House," built by Wessels Ten Brock, in 1676. The cherty limestone in it shows little signs of weathering, excepting in the deepening of the furrows in the rock-face blocks. The irregular shaped surfaces of rubble-work do not show alteration and wear, as in the case of dressed faces. The variety of stone found in its walls, as in some of the other old houses indicates that "field stone" was used in these older constructions. With few exceptions the walls in these old buildings are undresssed stone and bricks, laid on their natural beds, and nearly all of it is limestone. Its durability is attested by its uniformity of condition. In the older walls the weathering has resulted in a roughening of some of the surface and a fading of color from blue to pale gray. Onondaga limestone, which is quarried in the city, furnishes material for heavy masonry, foundations and retaining walls.

* Letter of Cornelius Van Gaasbeck, Kingston, January 23, 1890.

Streets.—The Hudson river blue-stone, obtained at the quarries near the city is used for sidewalks and curbing. The roadways are paved and macadamized. The statistics of street work are as follows:*

Belgian block pavement	6,275 feet.
Cobble stone pavement	3,525 "
Telford and Macadam roads	23,800 "

OR IN MILES:

Block pavement, length	1.9 miles.
Telford road, length	4.5 "
Tram road, length	1.6 "

ALBANY

The amount of stone used in construction in this city is comparatively large, and a great variety is employed, owing to the facilities for getting it from the several stone districts which surround it. The canals and the river afford cheap freights from the north, west and south, and railway lines converge here as a centre, from all points of the compass. As the capital of the State it has among its structures of stone the several state buildings.

Granites, marbles, sandstones and limestones have all been used in the state, city and county buildings, and in the church edifices. Sandstones are more common in the fronts of mercantile buildings and in those of private dwelling-houses. In foundations, and in common wall-work, Schenectady blue-stone is most largely used, and from the quarries at Aqueduct and at Schenectady. Blue limestone also has been put in some of the heavier masonry. For the capitol substructure granite from the Adirondacks, and from Monson, Massachusetts, and a large amount of limestone from Willsborough, on Lake Champlain, from Kingston and from the limestone quarries of the Mohawk valley was used. Hudson river blue-stone is used extensively and

* Letter of Hon. James G. Lindsley, of Rondout, February 10, 1890.

in greater part as sills, caps, steps, and in trimming brick buildings of all kinds. Connecticut brownstone is seen in many of the fronts, and in the trimmings of brick buildings, but it is not now so generally used as it was formerly. The East Longmeadow sandstones have apparently taken its place, and they are now in demand, both for fronts and for all stone structures. Limestone has not been employed to the same extent here as in the cities of the central and western parts of the state. And the Indiana oolitic stone has not yet come into general notice as a building material.

A census of the stone fronts and all-stone buildings, taken for this report, gives the following statistics:

All-stone buildings	20
Stone fronts	174

As several of these all-stone buildings are very large, the amount of stone in them is equivalent to a much greater number of average city structures. The capitol alone is equal to many ordinary average city buildings.

The examples of stone construction to which reference is here made are classified by kinds of stone. And, first: granites are noted in the capitol, the United States Government building, the city hall, Stanwix Hall hotel, Albany Savings bank and Albany City bank. The first story of the capitol is a gray granite from Yarmouth, Maine. Some of the stones show brown spots on the surface, due to oxidation of the iron. There is also a noticeable efflorescence on some parts of the surface, owing apparently to the action of the water on the mortar. The beautiful gray and fine-crystalline granite of the upper stories, is from Hallowell, Maine. It shows no sign of deterioration by weathering. All of the granite in the capitol is cut and dressed blocks. The new city hall and county building, on Eagle street and diagonally across the park from the capitol, is one of the late Mr. Richardson's architectural monuments, in granite, from Milford, Massachusetts, trimmed with East Longmeadow

sandstone. The granite is pink in color, and the blocks are laid up in courses with rock-face fronts. The same combination of granite and sandstone is seen in the new Commercial Bank building, on State street near Broadway, and in the Young Men's Christian Association building, on North Pearl street. The United States Government building, at the foot of State street, is built of gray granite from Maine. That of the upper stories is said to be from the St. George quarries in Knox county. The stone in the lower story is coarse-grained, and is from Spruce Head Island, Maine. The Albany City bank building front, on State street, is from the same quarries. The Stanwix Hall hotel front, on Broadway, represents the Quincy granite quarries.

For interior, decorative work there are some fine examples in the capitol. The massive columns of polished red granite in the Assembly chamber are from Grindstone Island, Jefferson county; those of the Senate chamber are from Stony Creek, Connecticut; the pink granites in the columns of the library are from Bay of Fundy, Nova Scotia.

Marble has not been used to any considerable extent for exterior walls. The most prominent example is the state hall, built in 1835–42, of a dolomitic stone from Sing Sing. The stone is coarse-granular and friable. In the outer walls it is every where weathered to a bluish-gray color, and the surfaces are roughened by the decomposition and disintegration. Stones in the cornice, the sills, lintels and steps, where they are more exposed to the action of rain-water and to frosts, are, in some cases, much disintegrated, so as to be a mass of loosely coherent grains, and they are falling to pieces. The unsafe condition of the west front cornice, three years ago, necessitated its removal and the substitution of metal in its place. It appears probable, from a remark of Prof. William Mather,* that the stone was not well selected.

* William W. Mather, Geology of the First District, Albany, 1843, p. 455.

In the interior work of the capitol, the Knoxville, Tennessee marble has been used, particularly in the senate chamber and in the court of appeals rooms; also, in some of the corridors. The panels in the side-walls in the former are of Mexican onyx. The Sienna marble, from Italy, is seen in the arches of the same room and in the fire-place of the court of appeals room.

On State street and Broadway there are several white marble fronts, notably the old museum building at the corner.

Of the various limestones, the more prominent constructions are: Hawk street viaduct, abutments of gray lime stone from Cobleskill; Emanuel Baptist church, State street, built in 1869–71, of unhewn, Onondaga gray limestone; Madison Avenue Reformed church (1881) of rock-face blocks, of blue limestone, from Willsborough, Lake Champlain; basement story of the Municipal building, South Pearl street, from the same quarries. In the last named the seams of argillaceous material, which are revealed by weathering, disfigure the stone.

The house of John G. Myers, State corner of Swan street, is a fine example of the oolitic limestone from Bedford, Indiana.

Caén limestone from France was employed in the trimmings of St. Joseph's Roman Catholic church, built in 1860. It has not proved a durable stone, and much of it in the facings of the doorways and windows and in the quoins and buttresses of the walls, has been replaced by Ohio sandstone. The disintegration and wear appears to have been most serious in the walls, and less so in the carved finials and mullions.

Potsdam sandstone is seen in the All Saints cathedral, and in several dwelling-houses on State street. The fronts of Nos. 286 and 290 State street, erected about twenty years, are of this stone with brown-stone trimmings. The stone shows no evidence of wear or disintegration. The house of

R. C. Pruyn, Englewood place, is a fine example of the Potsdam sandstone, in rock-face ashlar work, with dressed trimmings of brownstone. In the cathedral the stone is well selected generally and is laid in course work, the blocks having rock-face surfaces. Some of them are ribbon-like in appearance owing to the alternations of red and yellow lines or thin layers. The facings are of Connecticut brownstone.

Connecticut brownstone is noted in the Roman Catholic cathedral of the Immaculate Conception, on Madison avenue; in Tweddle hall, State and North Pearl streets; in the Delavan house (first story and trimmings); First National Bank building; and in numerous fronts on the business streets of the city. The cathedral, erected in 1852, is one of the most notable examples of stone which has been damaged through faulty construction. Excepting in the new, south tower, nearly all of the blocks are set on edge. The stone varies somewhat in texture, from fine-grained and shaly to coarse-grained, but all of it shows a tendency to scale and many of the fine-tooled surfaces have disappeared by reason of this exfoliation which has been so extensive. A part of the north wall has been re-dressed, and all of the exterior wall must be so treated or rebuilt.

The house fronts on Washington avenue and those on Broadway and State street do not show so much flaking.

The Massachusetts brown and red sandstones, from the East Longmeadow quarries, are to be seen in the new Jewish synagogue, Swan and Lancaster streets; the First Presbyterian church, corner of Willet and State streets, built in 1884; Calvary Baptist church, State street (first story); the Commercial Bank building, and the Albany County Bank building fronts on State street; basement story and trimmings of the new armory, Washington avenue; Young Men's Christian Association building, on North Pearl street; house of Grange Sard, on State street, and many other new buildings. In nearly all cases this stone is used in rock-face blocks, with dressed trimmings of the same.

Schenectady blue-stone is seen in St. Peter's Protestant Episcopal church, on State street; in St. Joseph's Roman Catholic church, Ten Broeck street (walls); in the Protestant Episcopal church of the Holy Innocents, corner of North Pearl and Colonie streets; in the Second Presbyterian church, on Chapel street, and in St. John's Roman Catholic church, Ferry street. The stone in the walls of St. Peter's church is nearly all natural-face blocks, and many of them have mellowed on exposure, to soft yellowish and light-brown tints, which give the building the appearance of age. Some of the stone shows a tendency to scale off at the corners and on the edges. The building is in the decorated Gothic style, and was erected in 1860. The trimmings are New Jersey freestone. In the Second Presbyterian church (1815), the stone show more signs of disintegration and the selection of the stone appears to have been made with less care. The durability and strength of the walls are not, however, impaired by the wear. A noteworthy example of Hudson river blue-stone can be seen in the house of H. G. Young, No. 425 State street, where the blocks are in course-work and have bush-hammered surfaces.

The Albany academy (built in 1815), is a fine architectural example of Nyack sandstone, and well-preserved.

Medina sandstone has not been used to any extent. It is seen in the first story of Tweddle hall, on State street; and the steps of the west staircase in the capitol, from the Albion quarries.

Of foreign sandstones there are in the capitol: the Dorchester stone, in the assembly staircase, and the Scotch sandstone in the south-eastern or senate staircase, and in the new rooms of the state library.

Streets.—The stone which is used for sidewalks and curbing is mainly Hudson river blue-stone, and from the quarries of Albany county and the river counties. The specifications require that the curbstones shall be dressed on edges. For crosswalks granite has been used in the

streets where the pavement has been renewed recently. There are isolated cases where granite sidewalks exist. A few examples remain of the old mica-schist flagstone walks, in some of the less frequented streets.

The cobblestone pavements are still in excess of all others, but in all of the more recently paved streets granite blocks or asphalt pavement has been laid. The lengths of paved streets, and kinds of pavements are given by the city engineer in his report as follows:*

Cobblestone	35 81-100	miles.
Granite block	16 39-100	"
Block (not granite)	1 42-100	"
McAdam road-bed	1 71-100	"
Asphalt	46-100	"
Total length	55 79-100	"

Troy

The quarries in the Hudson river group of sandstone, opened in the city, furnish stone for foundation and common wall work. "Schenectady bluestone," obtained at Aqueduct and Schenectady, also is used for foundations and cut-work. Limestone from Tribes Hill and Amsterdam, Willsborough Neck, on Lake Champlain, and Sandy Hill, Warren county, have all been used extensively. Connecticut brownstone has had the greatest use in fronts and in trimmings with red brick. Red sandstone from Massachusetts is noted in the newer constructions, and the Union National Bank building, on Fourth street, is an example of it.

Maine granite is seen in the city hall, and the Troy Savings Bank buildings. The county court-house is an old building of Sing Sing-marble. St. John's Protestant Episcopal church, Liberty and First streets, and the Troy club house, are new structures of brown sandstone. The Malden blue-stone is noted in 306–308 River street. St. Paul's Pro-

* Message of Hon. James H. Manning, Albany, 1890, p. 39.

testant Episcopal church, State and Third streets, built about fifty years ago, of Amsterdam limestone, and the Methodist Episcopal church, Fifth avenue and State street, of Willsborough Neck, are examples showing the durability of this limestone. In the first-named the clay seams are prominent and unsightly, although not impairing the strength. The parish house of the St. Paul's church is of Schenectady bluestone.

Reference is here made to the recently completed crematory in the Oak Hill cemetery, as a beautiful specimen piece of architecture in granite, from Westerly, Rhode Island.

The monument to General Wool, in the same cemetery, is remarkable as a monolith of gray granite, sixty feet in height, and quarried at Vinal Haven, Penobscot Bay, Maine.

Streets. — The sidewalks and curbing are mainly Hudson river blue-stone, although much brick continues on the less traveled streets.

The statistics of roadways are as follows : *

Cobblestone paved streets	5.5 miles
Granite block paved streets	9.12 "
Stone block paved streets	.5 "
Total stone-paved	15.12 miles

Schenectady

Quarries in the blue-stone and in the limestone of the Mohawk valley furnish stone for foundations and some dimension and cut-work. The so-called " Schenectady bluestone " is quarried within the city limits, on the east. For house-trimmings and for steps and platforms, limestone from quarries at Tribes Hill has been used largely, although not so generally as in former years, and, in the newer buildings, more brownstone and red sandstone are to be seen.

Among the stone buildings of the place reference is made to the following: The First Reformed church, Union and

* From P. H. Baerman, civil engineer, Troy.

Church streets, an ornate and beautiful structure whose walls are of Schenectady blue-stone, of natural-face blocks and trimmed with Connecticut brownstone, dressed limestone and Ohio sandstone. The stone in the walls was selected with care and shows no signs of decay. The weathered, faint brown and yellow surfaces, which in no wise impair the strength or affect the durability, give tone to the color and produce a pleasant impression.

St. George's Protestant Episcopal church, in North Ferry street, is an old structure, also of the bluestone, which shows its durability. The older walls are common rubble-work. There is some limestone with the bluestone. The Presbyterian church, Catherine and State streets, is a modern construction (1886) of the same bluestone, with water-table and sills of dressed gray limestone from Palatine Bridge. Memorial hall, Union college, shows the same stone, but with brown sandstone and Ohio sandstone in glaring contrasts of color. The Edison hotel, near the station, has the Longmeadow brown sandstone and Tribes Hill blue limestone, used effectively with brick. Other stone buildings are, the old court house, the Mohawk National bank and a dwelling (first story), on Union street.

Streets. — The statistics of the street work in stone, as estimated by William Gifford, city engineer, are:

Cobblestone paved streets	12 miles.
Medina sandstone block pavements	800 feet.
Streets paved with asphalt	2700 feet.
Total length of streets	50 miles.
Total length of sidewalks	32 "
Bluestone laid walks	20 "

Cohoes

This city is remarkable for the almost entire absence of all-stone buildings. A large amount of stone has been put in the foundations and basement stories of the large mills —

mostly Schenectady bluestone. For trimmings of brick stores and dwellings the same stone has had some use, although not so large as that of the Hudson river blue-stone. The Protestant Episcopal church, near the railroad depot, is the only large structure all of stone. The Schenectady bluestone in it shows many blocks weathered in various shades of yellow and green.

There are, in the city, streets paved *

With granite blocks	2.3 miles.
With Belgian blocks	2,000 feet.
With Medina sandstone	300 feet.
Or, a total of paved streets	2.8 miles.
The total length of sidewalk paved	9.1 "

Of the above about three miles is laid with composition tar pavement.

UTICA

In the city of Utica brick dominates, as a building material in the better class of dwelling-houses, in the church edifices and in the larger structures devoted to mercantile business and manufacturing work. A great variety of stone is used for water-tables, steps, caps, lintels, sills, pediments and string courses with brick walls. Sandstone from Frankfort and from Clinton is used in foundation and common wall-work, also, limestone from Canajoharie and from the Prospect quarries. The Trenton limestone from the last-named locality has been largely employed in trimming, and in axe-hammered, bush-hammered or pointed dimension-blocks, but is giving way, to some extent, before the tide of fashion, which is calling for sandstones. It still finds a large use in the smaller and less expensive buildings, and for platforms and steps it continues to be the best material here. The comparatively less cost in dressing the softer sandstones, and their employment in rock-face ashlar with brick, in ac-

* Letter of Edward Hayes, civil engineer, April 7, 1890.

cordance with the prevailing styles in larger buildings, has caused a relative decline in the use of limestone, particularly the dressed stone. And, as a result, sandstones from Massachusetts, New Jersey, Ohio, and from Higginsville and Oxford, in this state, are seen in the new and more massive structures. Marble and granite have found little use in wall-work. Among the more prominent stone buildings and examples in stone construction, the following are here mentioned: Grace Protestant Episcopal church, on Genesee street, of sandstone said to have been obtained from the New Hartford quarries, and trimmed with limestone from Prospect. The rusty-brown discoloration of the sandstone, noticed in many of the blocks, and the varying shades of color in them generally, gives to the building an old look. The limestone shows clayey seams. The Universalist church, on Seneca street, is of the same sandstone (front) and it exhibits a variation in color which mars the effect of an otherwise substantial-looking stone. The English Lutheran church, on Columbia street, near State street, is constructed of the Clinton sandstone, with Trenton limestone for trimmings. The Memorial Presbyterian church, court, corner of Garden street, also is of Clinton sandstone. The houses of Thomas F. Baker, and William F. Baker, on Genesee street, are fine examples in the modified Romanesque style of architecture of the Higginsville stone. In one, the stone selected, is of a reddish shade of color; in the other the blue sandstone is used exclusively. The blocks are laid in broken courses and are rock-face front. The trimmings are of the same stone, tooled. The houses of Frederick Gilbert and Thomas E. Kinney, on Genesee street, are built of the same stone. It is hard and durable, and in these buildings it looks well. The cost of working it precludes its more extensive use.

The state lunatic asylum building, in the western part of the city, a large structure, with Doric columns, is the best example of the Trenton limestone and the quarries at Prospect.

The new Young Men's Christian Association building, on Bleecker street, has its first story of Massachusetts red sandstone laid in rock-face ashlar work; and its trimmings of the upper stories of the same stone, partly tooled and partly rock-face.

The Oneida national bank, and Rowland's bank buildings, on Genesee street, are also of Massachusetts red sandstone, with brick.

The Mann block is said to have Haverstraw sandstone for trimmings; those of the Comstock building are red sandstone from Belleville, New Jersey; of the first national bank building, of Connecticut brownstone.

The United States Government building has granite walls in the basement story, and Ohio sandstone trimmings, with brick above.

The blue sandstone of Oxford, Chenango Co., is seen in the dressed stone caps and sills and the rock-face walls of the first story of the St. James hotel, on the corner of Whitesboro and Division streets.

White marble appears in the fronts of Mather's bank building, and in Nos. 52 and 54 Genesee street.

One of the older examples of the Trenton limestone (Prospect quarries), is in the basement story of Bagg's hotel, where the weathering is apparent in the more calcareous portions of the stone, and the blocks have a seamy aspect. The durability is not however affected seriously by the changes on the surface of the stone. The stone trimmings of the Reformed church on Genesee street, show similar surface weathering.

Other stone structures which may be referred to, are the city jail, of dressed gray limestone; the Williams building, of Prospect limestone and brick, and the Creeman building, of sandstone and brick, both on Genesee street.

Streets. — The sidewalks are mostly of blue-stone from Atwater, on Cayuga lake, and from the Hudson river. The

crosswalks are of Medina sandstone; the curbing is largely sandstone from Chenango county.

For roadways the Hammond sandstone block pavement was generally employed up to the introduction of the asphalt, of which there has been much laid in the residence streets.

F. K. Baxter, city engineer, reports that there are of paved streets, the following:

Hammond sandstone block, length	8	miles
Granite block	.2	"
Cobblestone	12	"
Telford and Macadam	2.12	"
Total length of stone sidewalks	40 miles	

Elmira

Elmira is a city of brick and frame structures, and remarkable for the small number of stone buildings. The Park Congregational church is constructed of blue sandstone, from Corning, laid in rock-face and in broken courses, and trimmed with a siliceous conglomerate from Pennsylvania. The sandstone is of various shades of yellow, and the want of uniform color gives it an old and weathered appearance. A large amount of Onondaga limestone, from the quarries near Syracuse, has been used in fine-cut sills, lintels, water-tables and steps, with brick walls. Good examples are in the court-house and county buildings. Sandstones from the Euclid quarries, Ohio, and from other localities have been introduced and found a limited use in the newer buildings.

The sandstone of local quarries, near the city, is used almost exclusively in foundations and in retaining-walls, and to some extent in curbing.

Streets. — Flagstone from Trumansburgh, and the quarries along the Delaware river, is used for sidewalks and crosswalks. The Medina sandstone has been used for the paving of roadways. A. P. Bovier, city engineer, reports "about

five miles of paved streets and twenty miles of stone side-walks." *

Binghamton

Although brick is the leading constructive material used in the larger and more important structures, much stone has been put in buildings erected during the past decade; and the city has some notable stone buildings. Of these, one of the oldest is the Christ Protestant Episcopal church, built of greenish-gray sandstone, from Bucklin's quarry at Oxford, Chenango county. During the past summer the north side was bright-green with a growth of algæ. The United States Government building (completed recently) is of Warsaw sandstone and Portage sandstone, The stones are cut with rock-face and are laid in broken courses, with fine-cut stone in the arched lintels, sills, water-tables, etc. Upon close inspection some of the blocks are noticed as having a rusty appearance, but as a whole there is a uniform shade of faint-greenish-gray which produces a pleasing effect. The Westcott building, on State street, is one of the most ornate new architectural structures, having blue sandstone from Warsaw in the three lower stories, and brick above, trimmed with the same stone. Oxford blue sandstone is seen in the new business building, on the corner of Henry street and Commercial avenue. It is used in rock-face blocks with red brick. Berea, Ohio, sandstone is being employed in the first story, and in trimmings for the upper stories, of a new building opposite, and on Henry street. Another new composite structure of brick and Warsaw sandstone, is the tall Ross building on Court street, corner of State. These new business buildings will give an opportunity to study the effects of weathering on these three sandstones, under similar conditions, and for a uniform length of time. Onondaga gray limestone has been

* Letter December 28, 1889.

employed, to a great extent for trimming with brick, and for street work. One of the most notable examples of this stone is the massive Susquehanna Valley bank building, on Court street. The stone is fine-cut and laid in courses. Sisson's block, on the same street, the Broome county court-house (basement story) and a front on the Court-House square are other noteworthy Onondaga limestone buildings; and, with red brick, the High school and the church opposite, on Court street. The use of this stone is, however, declining, and it is being replaced by sandstone.

Streets. — For sidewalks, flagstone from quarries on the Delaware river, between Hancock and Port Jervis, is most commonly used. And there is an aggregate length of eleven and three-fourths miles of street with seven-foot stone sidewalks, equivalent to twenty-three and one-half miles linear measurement.* Stone curbing, two and one-half feet by four inches thick, is laid on at least one-third of the streets as yet unpaved. None of the roadways are paved with stone, asphalt and wood being used.

Syracuse

As might be expected from the nearness of the quarries in the famous Onondaga limestone, Syracuse is built largely of limestone. Both the blue and the gray varieties are used — the former in foundations and rough wall-work, the latter in cut-work. This stone is seen in all the heavy masonry, and in nearly all of the older buildings. Sandstones from Ohio, Massachusetts and New Jersey, and from Potsdam, Warsaw and Granby have taken its place in some of the newer constructions. Granite has not been used to any extent.

The Onondaga gray limestone is seen in the new city hall, the United States Government building, St. Paul's Protestant Episcopal church, on Fayette street, May Mem-

* Letter of H. C. Merrick, City Engineer, December 26, 1889.

orial Unitarian church, and the Reformed church, on James street, St. Mary's Roman Catholic church, corner of Montgomery and Jefferson streets; in the Onondaga county savings bank; in the Astronomical observatory and hall of languages, Syracuse university; the house of Mr. White, on James street, Hogan block and the Peck building. The most beautiful examples of the Onondaga gray limestone are: the United States Government building, the stone of which is from the Reservation quarries; St. Mary's Roman Catholic church, the St. Paul's Protestant Episcopal church, the May Memorial church and the new city hall. In St. Paul's church there is a pleasing contrast between the fine-tooled stone, of light-gray shade, as seen in the spire and the trimmings, and the dark-gray, rock-face ashlar of the walls. These buildings are comparatively new, having been built during the present decade. The Onondaga county court house, whose walls are of blocks of uniform size and laid in regular courses, is one of the older buildings in which this stone has been used, and the sound condition of its walls are evidence of the durability of the stone. In some cases north-facing walls of Onondaga limestone are discolored or darkened in streaks by a fungus growth, but the stone is not apparently impaired by it. In St. Mary's Roman Catholic church this is noticeable. In the bush-hammered stone, as in the Government building, the style of dressing shows the corals in the rock, due to the crystalline nature of the coralline masses in the gray matrix. Another possible objection to this stone is the white calcareous deposits sometimes carried down over red brick walls, when used together. Examples of red brick trimmed with the limestone are seen in Durston Memorial building, on James street, the county clerk's office building, New York state armory building, the Von Ranke library, and others.

Sandstone from Fulton appears in the First Presbyterian church, Fayette and South Salina streets (built in 1840), and in St. James' Free church, on Locke street. The large per-

centage of stone set on edge in the walls of the first-named building has caused a rapid weathering, through flaking and the appearance of clay holes, and has given the structure an ancient look. More carefully laid stone, as in the St. James' church, is not as much weathered, although the building is not as old. Potsdam sandstone is represented by the "Florence," on South Salina street. Rock-face ashlar walls in the first story, and the trimmings with red brick above, make a substantial-looking front, and there is a blending of color in the red brick with this stone, which is pleasing. The Granby brown sandstone is seen in the Fay building on West Fayette street. Clay holes appear in the tooled blocks of the front. The recently completed (1889) John Crouse Memorial college for women is one of the finest examples of newer architectural design and of solid construction in the city. It is built of granite from Milford, and red sandstone from Longmeadow, Massachusetts. This composite arrangement of stone is effective and pleasing in appearance. The Third national bank building, on North Salina, corner of Willow street, and the Crouse stables are also of Massachusetts sandstone. New Jersey sandstone was noted in the Frazer building on South Salina street. Ohio sandstone has been used in the residence streets to some extent. It is cheaper than the limestone for cut-work; examples are the Syracuse Savings bank, on North Salina street, and in the Wieting Opera house, and the D. McCarthy building, on Washington street.

Streets.—The Onondaga limestone was formerly in favor for sidewalks, platforms and curbing, and it is seen in the older paved parts of the city. The newer laid sidewalks are largely Cayuga (planed) sandstone and Ohio sandstone. The Warsaw blue sandstone around the armory, Jefferson and Clinton streets, is notable for its evenness and its granular surface which does not become smooth and slippery as the limestone. Some flagging from Chenango county has been laid. The crosswalks are mainly of Potsdam sand-

stone. For roadways the Potsdam and Medina sandstones have been employed; and there are in the city: *

Streets paved with sandstone, total length	3.40 miles
Streets paved with cobblestone, total length	1.54 "
Streets paved with limestone block, total length	.16 "
Total	5.10 miles
Streets paved with block asphalt	.12 miles
Streets macadamized	47.00 "
Total length paved street	52.22 miles

Oswego

Oswego from its situation on the lake commands cheap water freight, and in this way stone from the west and from points on the St. Lawrence come to it. The principal building stone in use for common wall work is the coarse-grained, light-gray sandstone, of the Medina sandstone formation. It is quarried on the lake shore and within the city limits, north-east from Fort Ontario to the New York, Ontario and Western Railroad company's shops. For the heavy masonry of the breakwater in front of the city, and for locks and piers, Chaumont limestone has been used almost exclusively. Onondaga gray limestone, dressed, and in course work, appears in the county court house. The old Fort Ontario walls and structures are of sandstone from the local quarries. The United States post-office, and custom house building is of Ohio sandstone. The First Presbyterian and Christ (Protestant Episcopal) churches, are built of sandstone from local quarries. The Church of the Evangelists is of a spotted-red sandstone from Oswego Falls. One of the newer stone fronts is that of the Second National bank, in which the Granby sandstone, carefully selected, has been put. There are in all about a dozen stone dwelling-houses and business fronts.

* Annual report John B. Borden, City Engineer, 1889 page 69.

Streets. — The statistics of street work, furnished by N. J. Harris, city surveyor, are as follows:

Cobblestone pavement, total length	1.3 miles.
Block stone pavement, total length	.53 "
Macadamized streets, total length	2.18 "
	4.01 miles
Sidewalks — stone	7.00 miles.

The block pavement is mostly gray and red sandstone. The sidewalks are laid with blue-stone.*

Auburn

Auburn is on the Upper Helderberg limestone, and the quarries which have been opened in this formation have furnished a large amount of building material to the city; and the percentage of stone construction in the city is unusually high. The blue limestone is put in rubble-work and in common walls and foundations; the gray limestone is used for dimension work and for curbing, gutter-stone, platforms and house-trimmings. The Cayuga county courthouse is one of the old structures built of limestone. Its walls are discolored slightly by iron stains, resulting from the decomposition of pyrite in the stone. The city hall is of blue limestone. The state prison and its inclosing walls are of gray limestone. The First Presbyterian church, built in 1870, and the First Baptist church, in 1883, are beautiful examples of the gray limestone, in rock-face ashlar work, with ax-hammered and bush-hammered limestone trimmings. The rock-face and the ax-hammered and bush-hammered surfaces, when thus brought together, produce a pleasing effect by their not too great contrast in shades of color, varying from dark to light-gray.

Other notable buildings of limestone are: St. Peter's Protestant Episcopal church, St. Mary's Roman Catholic

* Letter, dated April 9, 1890.

church, the new arsenal, and Willard hall and Morgan hall of the Theological seminary. On Genesee street there are about twenty stone store fronts, and all about the city limestone buildings are to be seen.

Very little stone other than that from the local quarries has been used here. Perhaps the most beautiful example is the High school building, its first story in rock-face ashlar of Potsdam sandstone and Longmeadow, Massachusetts, brown sandstone trimmings. The bright-colored Potsdam stone looks well, associated with the sombre-looking Longmeadow sandstone. Another example of the Potsdam sandstone is seen in a new house on Genesee street. The Medina sandstone, from Albion, is seen in Gen. McDougall's house. Scotch sandstone appears in a national bank building on the same street.

Streets. — Of the eighty miles of streets in the city, about one mile is paved with Medina sandstone blocks. The aggregate length of flagstone sidewalks is about twenty miles. The flagstone is obtained from Trumansburgh.*

Rochester

The city of Rochester has within its limits several large quarries in the Niagara limestone, which supply nearly all of the stone needed in foundations, party-walls and common rubble-work. This stone is sold at six dollars per cord, delivered. It is sometimes dressed for rock-face ashlar-work also. The Medina sandstone formation affords an inferior building stone, but it is not now used.† The older mill buildings seen along the river are constructed of inferior grades of sandstone, and of limestone. In the newer mills and factories brick, with red Medina sandstone, is used generally. The newer mercantile structures are, also, largely

* Letter of D. F. Austin, City Surveyor, January 17, 1890.

† Formerly this stone was quarried in the bed of the Genesee.— Geology of the Fourth District, by Prof. Hall, p. 432.

trimmed with Medina sandstone. For heavy masonry limestone from Lockport and from Union Springs has been employed. The leading supply of stone for large construction and for house work is the Medina sandstone from the quarries at Holley, Hulberton, Albion and Medina. For carved work the softer sandstones, as those of Massachusetts and Ohio, and the Connecticut brownstone, are preferred on account of their cheapness.

The small amount of granite and marble used is a notable fact. Among the numerous structures of Medina sandstone the more prominent and public buildings, which may be referred to here, are the following: the United States Government building, corner of North Fitzhugh and Church streets, completed recently, and of rock-face ashlar, in courses with trimmings of the same stone, dressed; the First Baptist church, on North Fitzhugh street; Sibley hall, Anderson hall, and the new hall of physics, of the Rochester university; St. Patrick's Roman Catholic cathedral, Platt and Frank streets; house of George C. Hollister, East avenue; Commercial National bank building, and the Wilder building fronts, both on East Main street; Trinity Protestant Episcopal church, corner of Jones avenue and Frank street; Western House of Refuge; Church home, on Mount Hope avenue; and the new restaurant building (basement story) of New York Central and Hudson River railroad company. The red sandstone has been used in the above-mentioned structures. There are on East avenue several other large and costly residences, in which the red Medina sandstone has been employed with much taste. And nearly all of the newer houses have the basements of rock-face, broken course, stone work. Associated with brick, the H. H. Warner house is a fine example in modified Romanesque style. Of the gray or white Medina sandstone, the new St. Michael's Roman Catholic church (1888–89), corner of Clinton and Evergreen streets, is a large and massive structure, with walls of rock-face broken ashlar, and

trimmed with Ohio sandstone. This stone is from the Whitmore quarries at Lockport. The First Presbyterian church, corner of Plymouth and Spring streets, is another example of the white Medina sandstone. The Warner Astronomical observatory, also, is of the Lockport white sandstone. On West avenue the large St. Mary's hospital, and a large and costly private house, are constructed of gray Medina sandstone. In the latter case the red Medina is used for the basement story.

Sandstone from Warsaw has been used in the city hall, (first story) built in 1873; in the Arcade building, East Main street, and in the trimmings of the high school building. The upper stories of the city hall are of Medina sandstone. The exfoliation and pitting of the Warsaw stone in the city hall is a serious defect, and an illustration of an inferior stone. It was taken from an old quarry, which is now abandoned. Another building of Warsaw stone is the Smith and Perkins block, on Exchange street. Little Connecticut brownstone is seen in this city. The Rochester Savings bank, corner of West Main and South Fitzhugh streets, is the largest and most imposing architectural example. The red and brown sandstones of Longmeadow, Massachusetts, and the lighter red stones, especially, are apparently in favor with architects here. The Safe Deposit building, on Exchange street, the new German Insurance building, corner of West Main street and Irving place (first and second stories and trimmings) and the Glenny store, East Main street, are large structures with sandstone fronts. In limestone the New York Central and Hudson River railroad viaduct is a large and massively built piece of work. The stone is mainly from quarries at Union Springs, with a little red Medina sandstone. The fronts, Nos. 134–136 East Main street, are white marble. Of foreign stone the most notable and prominent construction is the front of the new, tall building of Ellwanger and Barry, built of Scotch sandstone.

Streets. — The Medina sandstone is the favorite for street work. Nearly all of the curbing and crosswalks are of the red or spotted sandstone, and it is admirably adapted to these uses. For sidewalks, also, it is used, but not so largely. Blue-stone from Pennsylvania quarries, sandstone from Atwater, on Cayuga lake, Trumansburgh, in Tompkins county, and the Ohio sandstones are all in demand for flagging. Artificial stone is also coming into use and replacing the Medina stone in the construction of sidewalks. The inequalities in the surface of the smaller, Medina flagstones hold little pools of water, and it is not as dry a walk as the more even surfaces of blue-stone. For roadways, the Medina sandstone block pavement is laid on sixteen and one-half miles in length of streets in the city limits.* The stone laid here, as, also, in Buffalo, are not the dressed Medina paving blocks, but the less expensive, natural-face blocks, costing about two dollars and fifty cents per square yard, and do not represent the best output of the quarries in the Medina sandstone district. It wears well, however, and is not as slippery as granite when wet. On the fine residence streets, as East avenue, Lake avenue, West avenue and others where there is much driving for pleasure, asphalt is being laid instead of stone. The total aggregate length of stone block roadway is comparatively below that of other cities in the state.

Buffalo

Buffalo obtains its building stone from local quarries within the city limits, from quarry districts in the western part of the state, and, through its advantageous situation on the lake, and low rates of freight, stones from Ohio and Lake Superior region. The even-bedded, gray limestone of the corniferous formation is quarried extensively, for use in foundations of all structures, and for common

* Letter of Gilbert Brady & Co., 37 South Fitzhugh street, Rochester, January 3, 1890.

rubble-work. It is hard, dense and strong, and is not dressed. It sells in the city at six dollars per cord. The Williamsville quarries, ten miles north-east of the city afford a gray limestone for cut and dimension work. On account of the expenses of cartage and of dressing, its use is limited to trimming brick buildings, and for steps and plat forms, and is being crowded out of the field, it once held, by the more cheaply dressed and warmer-colored sandstones. The Medina sandstone formation furnishes the greater part of the building stone for cut and dimension-work in this city. And the quarries at Albion, Holley, Hulberton and Medina produce nearly all that is used here. The red Medina stone is seen in the largest and most expensive structures, and the best architectural work, and it is used both for the walls and trimmings; and many of the large business buildings are of red brick and sandstone. It is employed in rock-face and in fine-tooled and bush-hammered blocks, for sills, caps, lintels, water-tables, string courses and pediments, and for basement walls. Its red color combines with red brick to produce a pleasing effect. On Delaware avenue, Porter avenue and North street, and other streets, it has been used extensively, in private dwellings.

The gray or white Medina sandstone was formerly much used, but it has been neglected of late, because of the general demand and preference for red stone. It is seen in many of the older buildings.

The Ohio sandstones, also, have relatively declined in the extent used, notwithstanding their lower cost, wherever there is much carved-work required. For trimmings they have had an extensive use.

Among the newer kinds of stone which are now in the market are the red sandstone from Portage, Lake Superior, the Granby red sandstone and the sandstone from Neshoppen, Pennsylvania. The first-named is obtainable in large blocks, and is easily worked. It sells at one dollar and twenty-five cents per cubic foot.

A census of the stone buildings in the city, made recently and for this report, gives the following statistics:

Stone buildings and stone fronts	155
Stone sheds and smaller buildings	15
Total	170

Inasmuch as all buildings in part of stone are not included in the above enumeration, these figures fail to give a correct view of the extent to which stone enters in construction work in the city.

The average ruling prices for stone in Buffalo, are reported as follows:

Limestone, city quarries, per cord	$6 00
Limestone, Williamsville, per cubic foot	60
Sandstone, Medina, per cubic foot	85
Sandstone, Albion, per cubic foot	1 00
Sandstone, Ohio, per cubic foot	55
Sandstone, Portage, Lake Superior, per cubic foot	$1–1 25

The red Medina sandstone is represented by many of the largest and most costly architectural buildings of the city. The more conspicuous are the following: St. Paul's Protestant Episcopal church, at the intersection of Erie, Main and Church streets, an imposing edifice whose walls are dressed stone, in broken courses and trimmings of fine-tooled stone; they were not impaired seriously by the fire which consumed all the combustible interior and roof, two years ago. The Young Men's Association library building, of sandstone from the Albion quarries, with brick and terra-cotta—a pleasing combination of material and blending of color. The Buffalo City Savings bank, and the Western Savings bank, on the west side of the square, and opposite the library, are of red sandstone; the former from the Albion quarries. In the latter building, the hammer-pointed stone in regular courses, has rather a dingy aspect owing to the accumulation of soot from bituminous coal fires.

The German Young Men's Association building, on Main street, built in 1886, a large and ornate structure, shows the Albion stone with Connecticut brownstone and brick walls above the first story. The steps are notable examples of even-grained stone, and of extraordinary length. Another building near the last named, is the St. Louis Roman Catholic church, whose walls are rock-face ashlar work, with trimmings of the same stone, fine-tooled. Trinity Protestant Episcopal church, on Delaware avenue, built in 1884, of Albion sandstone, is remarkable for its beautiful, light-red and warm shade of color, as contrasted with the adjoining old church edifice, which is of gray limestone. The Delaware Avenue Methodist Episcopal church (1874), is a large and stately building of dark-red Medina sandstone. The Iroquois hotel has its trimmings of fine-tooled stone and first story piers of rock-face blocks of red sandstone from Hulberton. The Young Women's Christian Association building, at Niagara and Genesee streets, the Courier building, on Main street, the new municipal building, the Star theater, Genesee and Pearl streets, are other examples of red Medina sandstone. In the new Broezel building, Seneca street, the sandstone from the Holley quarries was used, with red brick. The new synagogue, in course of erection, has Granby brownstone as trimming with the Medina sandstone. The Niagara hotel, the new chapel of the First Presbyterian church, in the north-west quarter, and the Griffin house on Summer street, are notable representatives of the Albion stone. On Delaware avenue, Bishop Ryan's residence and the chapel adjacent; the Pardee house, and the Gratwick house, are costly structures of red Medina sandstone. In the Pardee house the rock-face stone gives a remarkably massive and pleasing effect. The Hulberton quarries are represented in the chapel, corner of North street and Linwood avenue. The State asylum and St. Michael's Roman Catholic church, the latter on Washington street, are older

buildings of red Medina sandstone, and show the effect of age in their walls darkened by the smoke of years.

The Central Presbyterian church, on Genesee street, is built of the gray Medina sandstone. The Langdon house, Delaware avenue, is a fine architectural effect in white Medina sandstone, from Lockport quarries. In the business quarters there are several old buildings of the gray Medina sandstone. St. John's church, Washington and Swan streets, is one of the older buildings of gray limestone, and its black walls show the objection to light-colored stone in a city where bituminous coal is used. St. Joseph's Roman Catholic cathedral, Franklin and West Swan, is another old and massive structure in which the gray limestone is trimmed with the Ohio sandstone. St. Ann's Roman Catholic church, Broadway and Emslie street, is of Lockport limestone. The county jail, Calvary Presbyterian church, on Delaware avenue, and the houses, No. 175 North and No. 245 Porter avenue, are other examples of gray limestone construction.

Although the Ohio sandstones have been used so much in trimmings with other stones, there are no large buildings, except the United States custom house and post-office, built entirely of Ohio stone. Comparatively little Connecticut brownstone is seen. The most important structure is that of the Bank of Erie county, on the south-west corner of Main and Court streets. The uniform shade of color in it is noticeable, as contrasted with the dark-red and slightly variegated appearance of the Medina sandstone in the Western Savings bank building on the opposite side of the street.

The Portage, Lake Superior, red sandstone appears in the house of ex-Mayor Becker, No. 543 Delaware avenue. Granite, from Maine, is represented by the massive city and county hall, and the gray stone of this building, erected in 1876, begins to look dingy.

Streets. — The streets are generally paved, either with Medina blocks or asphalt pavement. The average price at

which the sandstone block pavement is put down is two dollars per square yard ; the asphalt costs three dollars. The total aggregate length of stone pavement, according to the mayor's report, on January 1, 1889, was 127.14 miles. In the sidewalks some Ohio sandstone and some blue-stone from Pennsylvania have been used, but the Medina sandstone predominates. On the older walks, three lines of stones, which are three feet by two feet, are laid, making a walk six feet wide. Larger flagstones, and, generally, thicker stone, with smooth surfaces, are now put down. The total length of paved sidewalk is estimated at two hundred miles, of average width of five feet. *

Lockport

Lockport is a small city of stone. The United States census of 1880 reported that seven and five tenths per cent of its buildings were all-stone, and four per cent partly of stone. A count made for this report gives the following statistics :

All-stone buildings	266
Stone fronts and rears	67
Total	333

A peculiarity practiced here in construction is in putting brick fronts with stone side and rear walls.†

Formerly the gray and the mottled, red and gray Medina sandstones, from quarries north of the place, were much used in building, and many of the older structures in the lower part of the city, are of this sandstone. These quarries were opened first in 1824. The gray limestone of the Niagara period, which runs across the city in a bold ledge, is known from the quarries here as Lockport gray

* Letter of George E. Mann, City Engineer.

† The total number of all-stone and part stone buildings may be put safely at 340, as some of the latter class may have escaped notice.

limestone. It has had a larger use than the sandstone. The fine series of locks on the Erie canal, and the New York Central and Hudson River Railroad company's viaduct are constructed of this stone. Four church buildings and many dwelling-houses and stores are of this limestone. It has been much used in trimming brick fronts. The excellence, durability and cheapness of the stone of these local quarries have met the demand for stone, and hence very little sandstone or other stone from outside has been employed. A noteworthy exception is the Niagara county court house, of Ohio sandstone.

For street-work in curbing and crosswalks the limestone answers well. Medina sandstone is used both for sidewalks and for roadways. According to the report of the city surveyor, there are four miles of streets paved with the Medina sandstone.*

---

* Letter of Julius Frensee, City Surveyor, January 7, 1890.

V.

PHYSICAL TESTS AND CHEMICAL EXAMINATIONS OF BUILDING STONES.

A series of physical tests of the representative building stones of the state was undertaken for the purpose of ascertaining what their comparative values were for durable construction work. Chemical determinations were made of the amounts of certain constituents, which were supposed to be injurious or which were indicative of a composition liable to attack, on long-continued exposure to atmospheric agencies, and, also, of those which, by their presence in certain associations, might explain the structure of the stone as determined by its cementing or binding material.

The stones were selected with especial reference to their value and the extent to which they were used in building and general constructive work. So far as possible, all the great classes of stone and the larger quarry districts of the state are represented. The granites of Grindstone island, Jefferson county, and of Keeseville, Essex county, represent the developed quarries in the northern part of the state. The marbles of Tuckahoe and Pleasantville are from the Westchester marble district. The Glens Falls, Plattsburgh and Gouverneur stones represent the marbles of the northern counties, so far as they are worked to extent; the calciferous sandrock and magnesian limestone are represented by the Sandy Hill limestone; the limestones of the Mohawk valley are represented by those from Tribes Hill, Canajoharie and Prospect; the St. Lawrence valley by the Chaumont stone; the Onondaga gray limestone by a specimen from the Reservation quarries; the eastern Upper Helderberg formation by the Cobleskill stone; the Upper Helderberg limestones of the western-central coun-

ties by the Auburn and Union Springs stones; the corniferous limestone by the Williamsville quarry specimen.

The Potsdam sandstone is represented by the specimen of the Potsdam Red Sandstone Company; the Hudson river blue-stone by the Bigelow Blue Stone company's specimen, from quarries near Malden, and by the Oxford blue sandstone; the Medina sandstone by the stones from Albion and Hulberton; the eastern extension of the same formation, by the Oswego Falls sandstone; the sandstones of the Portage geologic epoch, by the Portage and Warsaw sandstones; the Chemung, by the Olean sandstone.

For the purpose of comparison with extra-limital stones, which are used extensively in the cities of the state, the following representative specimens were included in the series: granite, Hallowell, Maine; limestones, oolitic, from Indiana and Kentucky; fine-grained and coarse-grained brown sandstones, from the large quarries at Portland, Connecticut; the Kibbe, Maynard and Worcester sandstones, from East Longmeadow, Massachusetts; Ohio sandstone, from Berea, in that state; Lake Superior red sandstone, from Portage, Michigan; Belleville sandstone (freestone), New Jersey; Potomac red sandstone, from Bristow, Virginia; and Nova Scotia sandstone.* As far as possible, the stone of the quarries selected was, in nearly all cases, above the average in quality. The comparison is, therefore, between the best representatives or types of the several kinds and quarry districts.

The chemical work and the physical tests were made in accordance with my direction, at the laboratory of the Rutgers College Scientific School, New Brunswick, N. J., by F. A. Wilber, professor of analytical chemistry.

---

*The specimens of Massachusetts sandstone were kindly furnished by Messrs. Norcross Brothers, of Worcester, Massachusetts; the Connecticut sandstones, by the Brainerd Quarry Company, of Portland, Connecticut; those from Berea, Ohio, Portage, Lake Superior, Belleville, New Jersey, and Nova Scotia, and the limestones from Kentucky and Indiana, by R. Gill & Sons, foot of East One Hundred and Sixth street, New York.

Tests of compressive and tensile strength were not made of these specimens, inasmuch as data of this kind are to be had in the case of nearly all of the varieties of stone in this series. Besides, the importance of such tests of strength has been overestimated. All of the better quarry stone of the state is strong enough for the ordinary construction, as wall work. Only in exceptional cases is greater strength requisite, as in large arches where the thrust is severe, and in columns and piers supporting a great weight.*

As has been well said, "the problem is not what will a selected and carefully prepared sample of the stone bear to-day, but what will it bear after many seasons' exposure to heat and frost. For all ordinary purposes of construction the excess of strength of any stone over 15,000 pounds per square inch is of little value excepting so far as it denotes density, and hence greater resistance to atmospheric influences." †

* The compression in the Washington monument, a column 600 feet in height, *is* $18\frac{02}{100}$ *tons per square foot, whereas the strength of the marble used, is* 517 *tons, or less than the resistance of the weaker stones.* Julien, U. S. Tenth Census, tenth volume, p. 359.

† George P. Merrill, hand-book and catalogue of collection of building and ornamental stones, in the United States National museum. Rep. Smithsonian institution, 1885–'86, part II, page 490.

REPORT OF PROF. FRANCIS A. WILBER.

Prof. JOHN C. SMOCK, *State Museum, Albany, N. Y.:*

DEAR SIR:—Following your instructions I visited, during July and August, 1889, all the quarry districts of the state of New York designated by you, and collected specimens of the different varieties of building stone found in them. The samples, reported upon later, were, with two exceptions, taken either by the quarry owners or their foremen, or by dealers who handled large amounts of the particular stone. The samples for examination were prepared, after reaching my laboratory, by sawing or cutting small blocks, as nearly cubical as possible. All prepared samples were carefully examined, before using them, in order to see that no small portions had been started from them during preparation, the subsequent loss of which might have vitiated the results obtained.

It should also be stated that quarry-owners were specially requested to select the best possible specimens of stone from their respective quarries, and, with two exceptions, all samples taken were from blocks which had been quarried for some time.

In addition to the specimens collected in the state of New York, I received from you samples of a number of the leading building stones from localities outside the state. They were subjected to treatment exactly similar to that given those collected by me.

The tests made were uniform in every respect. All the limestones and marbles were subjected to a partial chemical analysis, to determine their calcium-magnesium ratio, and the corresponding amounts of calcium and magnesium carbonates computed. The siliceous residues, in each, when treated with dilute hydrochloric acid, were also determined. The only chemical work done upon the sandstones, was the determination of the amount of iron contained in each, and its state of oxidation. The results obtained in the chemical work are given in the accompanying table, in columns 7, 8, 9, 10, 11, 12 and 13.

The following comparative physical examinations were made, viz.:

1. Determination of the specific gravity.

2. Determination of the percentage of water absorbed by the dry stone.

3. Determination of the effect of continued action of carbonic acid gas on the wet samples.

4. Determination of the effect of continued action of sulphurous acid gas on the wet samples.

5. Determination of the effect produced upon the samples by dilute sulphuric acid.

6. Observation of the effect upon the samples produced by sudden and repeated changes of temperature.

7. Observation of the effect upon the samples of high temperature with sudden cooling.

The results of these examinations appear in the table in columns 5, 14–17–20, 22, 23, 24.

Description of the methods used in the above physical examinations.

1. Specific gravity.—This was determined by weighing the specimens, previously dried, to a constant weight at a temperature of 212° F., then immersing them in cold water, distilled, freed from air by boiling. The vessel containing the specimens was placed in the receiver of an air-pump, and a partial exhaustion of the air of the receiver very soon allowed the water to completely saturate the specimens. They were then weighed in water and the specific gravity computed in the usual manner.

$$\text{Specific gravity} = \frac{\text{Weight of dry specimen in air}}{\text{Weight of dry specimen in air} - \text{Weight of specimen in water}}$$

The weighings were made upon a Becker's analytical balance, and the samples used weighed from twenty-five to fifty grams. The weight of a cubic foot of each stone was computed from the obtained specific gravities, and the results will be found in column 6 of the table.

2. Determination of the percentage of water absorbed by the dry sample.—Specimens weighing about fifty grams were used. They were dried in an air-bath to a constant weight, at 212° F., and were then immersed in cold (previously boiled) distilled water, and after complete saturation were removed, one by one, from the water, their surfaces quickly dried with blotting-paper, and were again weighed. The percentage gained in weight by the saturated sample was then computed.

$$\text{Per cent gained} = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of dry sample}} \times 100.$$

See column 14.

3. Determination of the effect of continued action of carbonic acid gas upon the wet samples.—The water-saturated samples used in determining the per cent of water absorption were put upon a perforated shelf under a large bell-jar. The bell-jar was placed in a shallow pan, and enough water poured into the pan to make a water-seal for the bell-jar. Inlet and exit-tubes were introduced into it and a stream of washed carbonic acid gas passed into the jar until all air was expelled. The openings were then closed and the contents allowed to stand three days at a temperature of about 70° F. Carbonic acid gas was again passed in, and this operation was repeated, at intervals, during the fifty-two days of the continuance of the test. The samples were then removed and soaked for four days in distilled water, and were afterward dried in an air bath, at a temperature of 212° F., to constant weight. The per cent of loss was calculated.

$$\text{Per cent loss} = \frac{\text{Weight of dry sample before treatment} - \text{Weight of dry sample after treatment}}{\text{Weight of dry sample before treatment}} \times 100.$$

There was no perceptible change in the appearance of the samples after treatment.

The loss per cent appears in column 17.

4. Determination of the effect of continued action of sulphurous acid gas upon the wet samples.— The weight of specimens used was about fifty grams each. The treatment in this test was similar in all details to the preceding one, save that sulphurous acid gas was used instead of carbonic acid gas. The exposure in this test was for thirty-one days.

5. Determination of the effects produced upon the samples by treatment with dilute sulphuric acid.— Small cubes, three-fourths of an inch on a side, were used for this test. The samples were dried in a water bath at 212° F., to a constant weight. They were then placed upon a perforated support and immersed in dilute sulphuric acid. The acid solution contained one per cent of sulphuric acid, H_2SO_4, and the volume used at once was two gallons. After an immersion of forty hours the acid was drawn off and replaced by a fresh supply. This remained upon the samples twenty-four hours, when it was run off and a third fresh portion added, which was allowed to remain eight hours. It was then drawn off and a gentle stream of clear water passed through the vessel for some time, until the samples were entirely cleansed from the effects of the solvent action of the acid. They were then carefully removed to the water bath and dried at 212° F., to a constant weight.

$$\text{Per cent of loss} = \frac{\text{Weight of sample before treatment} - \text{Weight of sample after treatment}}{\text{Weight of sample before treatment}} \times 100.$$

The comparative effects of this test will be found in column 22 of the table.

6. Determination of the effects produced by repeated alternate freezing and thawing.— The specimens used for this test weighed from three hundred to four hundred grams. They were saturated with moisture and then placed in a closed vessel, which was surrounded with a freezing mixture of ice and salt. After an exposure of about twelve hours the vessel was opened and the samples found frozen solid. They were removed, carefully examined to discover any flaws or cracks, and at once put into an air-bath at 212° F. This treatment was continued about twelve hours when the samples were removed and at once put in water of a temperature of 40° F. After cooling they were again examined for checks or flaws and the preceding treatment was repeated. Seven successive treatments were made the samples being examined after each treatment. Results of this test are in column 23.

7. Effects produced in the samples by high heat and subsequent rapid cooling.-- Small cubes of the dry samples were used for this test. They were closely packed in the closed muffle of a Hoskins assay furnace. A copper rod was inserted in the opening at the top of the muffle and its lower extremity brought to the center of the mass of cubes, an opening having been left for the purpose. This lower end could be seen from above without removal of the rod. Heat was then applied and the blast gradually increased until an intense heat was produced. The copper rod was closely observed

	Effect upon the stone of high temperatu
....	Vitrified somewhat, color destroyed,
....	Color changed to a brownish red, stre
....	Color changed to dirty pale red, stre
....	
....	
....	Fully calcined; crumbled to the touc
her........	Fully calcined; crumbled to the touc
....	Fully calcined; crumbled to the touc
....	Fully calcined; crumbled to the touc
....	Much calcined; crumbled with a blo
....	Fully calcined; crumbled to the touc

TABLE

OF COMPARATIVE PHYSICAL AND CHEMICAL TESTS OF SOME REPRESENTATIVE BUILDING STONE.

1 Analytical number.	2 Kind of stone.	3 NAME OF QUARRY.	4 Locality of quarry.	5 Specific gravity.	6 Weight in pounds of one cubic foot.*	7 Per cent insoluble in dilute hydrochloric acid.	8 Per cent of lime CaO.	9 Equivalent amount of calcium carbonate.	10 Per cent of magnesia MgO.	11 Equivalent amount of magnesium carbonate.	12 Per cent of ferrous oxide FeO.	13 Per cent of ferric oxide Fe_2O_3.	14 Per cent of water absorbed by dry stone.	15 Pounds of water absorbed per cubic foot.*
			GRANITES.											
C. 2074	Granite	Forsythe's	Grindstone Island, St. Lawrence Co	2.7139	169.13								1.550	2.62
C. 2075	Granite	Au Sable Granite Works	Keeseville, Essex Co	2.7551	171.69								0.066	0.11
C. 2190(a)	Granite		Hallowell, Maine	2.6519	165.27								0.410	0.68
C. 2190(b)	Granite		Hallowell, Maine	2.6543	165.39								0.370	0.62
C. 2190(c)	Granite		Hallowell, Maine	2.6556	165.52								0.340	0.56
			MARBLES.											
C. 1978	Marble	New York Quarry Co	Tuckahoe, Westchester Co	2.8679	178.72	0.91	30.63	54.69	20.77	43.62			0.140	0.25
C. 2068	Marble	Snow flake Marble Co	Pleasantville, Westchester Co	2.8705	178.88	0.29	30.69	54.80	20.53	43.11			0.150	0.27
C. 2028	Marble	Finch & Pruyn	Glens Falls	2.7184	169.41	30.33	30.18	53.90	6.94	14.57			0.080	0.14
C. 1979	Marble	St. Lawrence Marble Co	Gouverneur, St. Lawrence Co	2.7561	171.76	1.39	51.57	92.09	3.29	6.90			0.160	0.27
			LIMESTONES.											
C. 1976	Limestone	Sandy Hill Quarry Co	Sandy Hill, Washington Co	2.7641	172.26	2.735	28.54	50.97	9.71	20.38			0.140	0.24
C. 1974	Limestone	Burlington Manufacturing Co	Plattsburgh, Clinton Co	2.7096	168.79	1.55	53.13	91.87	0.90	1.89			0.145	0.24
C. 2022	Limestone	Hurst & Son	Tribes Hill, Montgomery Co	2.7181	169.39	2.18	53.57	95.68					0.140	0.24
C. 2020	Limestone	A. C. & C. H. Shafer	Canajoharie, Montgomery Co	2.7267	169.93	10.06	46.92	83.72	1.67	3.51			0.070	0.14
C. 2065	Limestone	Evan S. Thomas	Prospect, Oneida Co	2.7250	169.82	2.63	53.10	94.82	0.79	1.66			0.140	0.24
C. 2073	Limestone	Adams Bros	Chaumont, Jefferson Co	2.7153	169.36	1.58	49.86	89.03	0.80	1.68			0.070	0.12
C. 2019	Limestone	Wm. Reilly	Cobleskill, Schoharie Co	2.7139	169.13	2.26	53.86	96.18	0.12	0.25			0.109	0.19
C. 2069	Limestone	Hughes Bros	Onondaga Reservation, Onondaga Co	2.7086	168.63	1.52	53.76	96.00	0.60	1.26			0.140	0.24
C. 2070	Limestone	P. Smith	Union Springs, Cayuga Co	2.7105	168.92	5.15	51.52	92.00	0.80	1.68			1.120	1.89
C. 1975	Limestone	Goodrich's quarry	Auburn, Cayuga Co	2.7230	169.69	2.33	52.97	94.59	1.04	2.18			0.120	0.20
C. 2102	Limestone	D. & H. Fogelsonger	Williamsville, Erie Co	2.7079	168.52	3.82	52.33	93.44	0.70	1.47			0.160	0.27
C. 2312	Limestone (oolitic)		Bowling Green, Kentucky	2.6961	168.02	1.24	54.71	97.69	0.18	0.37			6.17	10.36
C. 2318	Limestone (oolitic)		Indiana	2.6023	162.17	0.34	53.24	95.07	0.41	0.86			4.52	7.33
			SANDSTONES.											
C. 2078	Sandstone	Potsdam Red Sandstone Co	Potsdam, St. Lawrence Co	2.6010	162.28						0.36		2.080	3.375
C. 2079	Hudson river blue-stone	Bigelow Blue-stone Co	Malden, Ulster Co	2.7515	171.47						4.63	0.79	0.820	1.40
C. 2070	Sandstone	Oxford Blue-stone Co	Oxford, Chenango Co	2.7113	168.97						3.46	0.16	1.110	1.876
C. 2021	Sandstone	Albert Shear & Co	Duanesburgh, Schenectady Co	2.6991	168.21	70.12	9.87	17.54	1.84	3.86			0.880	1.48
C. 2084	Sandstone	Hughes Bros	Oswego Falls, Oswego Co	2.6249	163.59						0.59	1.71	3.330	5.78
C. 3084	Sandstone	Gilbert Brady & Co	Albion, Orleans Co	2.5989	162.07						0.51	0.09	2.370	3.81
C. 2225(a)	Sandstone	M. Scanlon	Hulberton, Orleans Co	2.5852	161.09						0.43	0.87	2.48	3.99
C. 2225(b)	Sandstone	M. Scanlon	Hulberton, Orleans Co	2.5827	160.97								2.45	3.94
C. 2225(c)	Sandstone	M. Scanlon	Hulberton, Orleans Co	2.5865	161.16								2.21	3.56
C. 2080	Sandstone	Portage Blue-stone Co	Portage, Wyoming Co	2.6850	168.01						3.89	0.39	2.970	4.99
C. 2081	Sandstone	Warsaw Blue-stone Co	Warsaw, Wyoming Co	2.6814	167.10						3.22	0.23	2.960	4.95
C. 2097	Sandstone	Olean Blue-stone Co	Olean, Cattaraugus Co	2.6024	162.02						3.01	0.33	2.120	3.43
C. 2185(a)	Sandstone	Kibbe	East Longmeadow, Mass	2.4788	154.48						0.58	1.81	4.370	6.75
C. 2185(b)	Sandstone	Kibbe	East Longmeadow, Mass	2.4706	154.52								4.450	6.88
C. 2185(c)	Sandstone	Kibbe	East Longmeadow, Mass	2.4802	154.55								4.230	6.69
C. 2186(a)	Sandstone	Maynard	East Longmeadow, Mass	2.4901	155.18						0.14	3.81	4.960	7.69
C. 2186(b)	Sandstone	Maynard	East Longmeadow, Mass	2.4918	155.30								5.080	7.89
C. 2186(c)	Sandstone	Maynard	East Longmeadow, Mass	2.4905	155.33								5.010	7.77
C. 2186(d)	Sandstone	Maynard	East Longmeadow, Mass	2.4942	155.42								5.090	7.91
C. 2187(a)	Sandstone	Worcester	East Longmeadow, Mass	2.4916	155.30						0.29	1.53	5.480	8.51
C. 2187(b)	Sandstone	Worcester	East Longmeadow, Mass	2.4916	155.30								5.470	8.48
C. 2187(c)	Sandstone	Worcester	East Longmeadow, Mass	2.4916	155.30								5.440	8.41
C. 2187(d)	Sandstone	Worcester	East Longmeadow, Mass	2.4885	155.11								5.320	8.25
C. 2188(a)	Sandstone (fine-grained)	Brainerd Quarry Co	Portland, Conn	2.6225	164.43						1.29	2.67	3.070	5.02
C. 2188(b)	Sandstone (fine-grained)	Brainerd Quarry Co	Portland, Conn	2.6181	163.15								2.980	4.73
C. 2189(a)	Sandstone (coarse-grained)	Brainerd Quarry Co	Portland, Conn	2.6351	164.21						1.29	2.86	2.600	4.27
C. 2189(b)	Sandstone (coarse-grained)	Brainerd Quarry Co	Portland, Conn	2.6308	163.96								2.740	4.49
C. 2189(c)	Sandstone (coarse-grained)	Brainerd Quarry Co	Portland, Conn	2.6207	163.34								2.710	4.41
C. 2317	Sandstone		Belleville, New Jersey	2.5618	159.67						0.22	0.90	5.32	8.49
C. 2315	Sandstone		Berea, Ohio	2.5697	160.06						0.72	0.30	6.80	10.88
C. 2316	Sandstone (Portage red)		Lake Superior, Mich	2.5289	158.17						0.29	0.80	8.71	13.78
C. 2314	Sandstone		Nova Scotia	2.6236	163.50						1.87	1.67	18.07	29.51
C. 2183(a)	Sandstone		Bristow, Prince William county, Va.	2.6166	163.07						0.43	5.26	3.630	5.90
C. 2183(b)	Sandstone		Bristow, Prince William county, Va.	2.6133	162.86								3.460	5.62
C. 2183(c)	Sandstone		Bristow, Prince William county, Va.	2.5903	161.41								3.310	5.31
C. 2318	Red roofing-slate	Penrhyn Slate Co	Middle Granville, Washington Co	2.8398	176.98						1.87	7.36	0.15	0.26

1 Analytical number.	16 Per cent of gain when acted upon by carbonic acid gas.	17 Per cent of loss when acted on by carbonic acid gas.	18 Pounds per cu. ft. gained or lost under treatment with carbonic acid gas.	19 Per cent of gain when acted upon by sulphurous acid gas.	20 Per cent of loss when acted upon by sulphurous acid gas.	21 Pounds per cu. ft. gained or lost under treatment with sulphurous acid gas.	22 Per cent of loss when treated with one per cent solution of sulphuric acid.	23 Effect upon the stone of repeated and rapid changes of temperature. 32° F to 212° F. 1	23 — 2	23 — 3	23 — 4	23 — 5	23 — 6	23 — 7	24 Effect upon the stone of high temperature with quick cooling. Heat used, melting point of copper. 1300° F to 1400° F.
GRANITES.															
C. 2074		0.006	0.010		0.007	0.012	0.13	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Vitrified somewhat, color destroyed, strength gone; crumbled with a blow.
C. 2075		0.002	0.003		0.017	0.029	0.06	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed to a brownish red, strength greatly impaired.
C. 2190(a)		0.029	0.048		0.024	0.039	0.08	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed to dirty pale red, strength gone; crumbled with a blow.
C. 2190(b)		0.021	0.035												
C. 2190(c)															
MARBLES.															
C. 1978		0.004	0.007		0.250	0.45	5.25	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2068		0.005	0.009		0.150	0.27	6.63	Unchanged	Unchanged	Unchanged	Unchanged	Slight checks	Nothing further	Nothing further	Fully calcined, crumbled to the touch.
C. 2028		0.007	0.012		0.120	0.24	2.56	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 1979		0.017	0.029		0.150	0.26	2.63	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
LIMESTONES.															
C. 1976		0.012	0.021		0.150	0.26	2.51	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Much calcined; crumbled with a blow.
C. 1974		0.023	0.039		0.190	0.32	2.20	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2022		0.028	0.047		0.160	0.31	3.03	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2020		0.012	0.020		0.160	0.27	2.62	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2065		0.017	0.029		0.150	0.25	2.97	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2073		0.008	0.014		0.091	0.15	2.95	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2019		0.010	0.017		0.130	0.22	2.58	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2069		0.021	0.035		0.201	0.24	2.81	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2070		0.011	0.019		0.082	0.14	3.77	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 1975		0.010	0.017		0.140	0.24	2.79	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2102		0.060	0.010		0.250	0.42	2.97	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; crumbled to the touch.
C. 2312		0.062	0.104	0.160		0.269	5.66						Slight flaw		Fully calcined; strength entirely gone.
C. 2318		0.087	0.141	0.019		0.031	5.83	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Fully calcined; strength entirely gone.
SANDSTONES.															
C. 2078		0.030	0.049		0.004	0.006	0.02	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color unchanged; no checks. Strength impaired but little.
C. 2079		0.032	0.055		0.003	0.005	0.20	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed to dull red, checked a little. Strength somewhat impaired.
C. 2070		0.021	0.035		0.080	0.135	0.20	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed to dull red, badly checked.
C. 2021		0.011	0.018		0.065	0.11	0.63	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Checked slightly, strength not greatly impaired, color changed to brownish red.
C. 2084		0.011	0.018		0.290	0.47	0.74				Checked	Badly checked	Still increase	Breaks open	Color brick red, strength not wholly impaired.
C. 3084		0.032	0.146		0.012	0.019	0.08	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color pale brick red; strength little impaired.
C. 2225(a)		0.046	0.074		0.061	0.098	0.08					Chipped slightly			Color changed to pale brick red; strength little impaired.
C. 2225(b)		0.037	0.059		0.078	0.125									
C. 2225(c)															
C. 2080		0.008	0.013		0.079	0.149	0.42							Slight scaling	Color changed to dull red; no checks. Strength impaired but little.
C. 2081		0.015	0.025		0.250	0.042	0.49				Slight checks		Slight further checking		Slight vitrification; checked somewhat. Color changed to dull red.
C. 2097		0.060	0.097		0.040	0.065	0.44				Slight checks	No change			Color changed to dull red, strength greatly impaired.
C. 2185(a)		0.046	0.071		0.055	0.085	0.12				Chipped			Chipped with bedding	Color changed from brown to brick red, strength gone. Crumbled with a blow.
C. 2185(b)		0.040	0.062												Color changed from brown to brick red, strength gone. Crumbled with a blow.
C. 2185(c)															Color changed from brown to brick red, strength gone. Crumbled with a blow.
C. 2186(a)		0.081	0.126		0.051	0.079	0.17				Chipped	Further chipping	Further chipping	Further chipping	Color unchanged; strength somewhat impaired.
C. 2186(b)		0.086	0.133												Color unchanged; strength somewhat impaired.
C. 2186(c)		0.076	0.118												
C. 2186(d)		0.060	0.093												
C. 2187(a)		0.074	0.115		0.146	0.226	0.11	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed from brown to dull red; strength gone. Crumbled with a blow.
C. 2187(b)		0.053	0.082		0.161	0.250									Color changed from brown to dull red; strength gone. Crumbled with a blow.
C. 2187(c)		0.068	0.106												Color changed from brown to dull red; strength gone. Crumbled with a blow.
C. 2187(d)															
C. 2188(a)		0.074	0.121		0.079	0.096	0.55				Chipped		Chipped	Chipped	Color changed from brown to dull red; strength gone. Crumbled with a blow.
C. 2188(b)		0.080	0.131		0.086	0.110									
C. 2189(a)		0.078	0.128		0.003	0.005	0.22	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Color changed from brown to dirty red; strength wholly gone. Crumbled to the touch.
C. 2189(b)		0.090	0.147												
C. 2189(c)															
C. 2317		0.031	0.049		0.040	0.064	1.01	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Strength entirely gone.
C. 2315		0.066	0.106		0.170	0.272	0.45					Slight flaw			Strength entirely gone; color changed to a light red.
C. 2316		0.005	0.008		0.100	0.158	0.36				Slight flaw				Not much weakened; color changed to brown.
C. 2314		0.025	0.041		0.020	0.033	0.20	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Greatly weakened; color changed to a dull red.
C. 2183(a)		0.079	0.128		0.180	0.294	0.11	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Slight vitrification; color pale red; strength little impaired.
C. 2183(b)		0.104	0.169		0.100	0.163									
C. 2183(c)															
C. 2318		0.004	0.007		0.070	0.124	0.07	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Partially fused; strength gone.

* 1 cu. ft. water = 62.321 lbs.

and as soon as its extremity began to show signs of melting the heat was guarded. At the first fusion the heat was turned off. The muffle was at once opened and the samples removed and laid upon a clay support in the open air. They cooled rapidly. As soon as cool their condition was noted. The strength of the cold samples was roughly tested by light blows with a hammer. The comparative results of this test will be found in column 24 of the table.

in order to prove the uniformity of different selected blocks of stone from the same quarry, small cubes were cut from different blocks of the same stone in several of the samples, and each of these cubes treated as an independent sample.

From C., 2183, three cubes, marked (a), (b), (c), were taken.
From C., 2185, three cubes, marked (a), (b), (c), were taken.
From C., 2186, four cubes, marked (a), (b), (c), (d), were taken.
From C., 2187, four cubes, marked (a), (b), (c), (d), were taken.
From C., 2188, two cubes, marked (a), (b), were taken.
From C., 2189, three cubes, marked (a), (b), (c), were taken.
From C., 2190, three cubes, marked (a), (b), (c), were taken.
From C., 2225, three cubes, marked (a), (b), (c), were taken.

The results of the comparisons of the same stone will be found in columns 5, 6, 14, 15, 17, 18. The agreement in these cases was so close that it seemed unnecessary to continue the comparisons further with other samples, and the cubes selected for the various tests may, therefore, fairly be considered representative ones for each particular quarry.

NOTES ON THE MICROSCOPIC STRUCTURE

Granite, Forsythe's Quarry, Grindstone Island, Jefferson County.— Mineral composition: quartz, feldspar (orthoclase and plagioclase) and muscovite; magnetite accessory. Both feldspars have lost many of their special characters. The cloudiness is not confined to the lines of cleavage but permeates the whole substance of the mineral. And there are no glassy crystals. The quartz is full of cavities. It carries myriads of acicular crystals, probably rutile. The quartz occurs in a structure known as mosaic — see Saxon granulite for an example.

Granite, Ausable Granite Works, Keeseville, Essex County.— Norite (?) constituent minerals: plagioclase, orthoclase, hypersthene and biotite; accessory minerals: hematite and pyrite. The feldspars are almost perfectly fresh, only traces of kaolinization appearing. The hypersthene is the next most abundant mineral. This is very fresh generally, though it shows slight traces of change along the cleavage lines. It has scales of hematite (?) included. It occurs in bladed crystals, one-eighth to one-quarter of an inch long; also in irregular grains. The biotite occurs in small, irregular crystals in limited quantity, but fresh looking. The pyrite is scarce and in small grains only.

Granite (weathered), Ausable Granite Works, Keeseville, Essex County.— The feldspars are kaolinized in spots. Some are mottled throughout, but generally the feldspars are fresh.

Granite, Hallowell, Maine.— Orthoclase, plagioclase, muscovite, biotite and quartz. The feldspars are kaolinized much more than they show, microscopically. None of them are fresh throughout. The quartz is in rough and irregular grains. Sometimes it is globular, and imbedded in the feldspar. Both the quartz and the feldspar are crowded full of

acicular crystals (undetermined). The muscovite and biotite are both fresh in appearance. The biotite is only an occasional mineral.

Sandstone, Potsdam Red Sandstone Company, Potsdam, St. Lawrence County.— Consists almost exclusively of quartz. The grains are subangular and quite clear. The cloudiness is due to minute crystals and to pores filled with either gas or fluid of some kind. Many of the grains show a secondary enlargement. The growth is indicated by a clearer rim of quartz, separated from the inner core by a ferruginous rim. The cementing material is almost wholly silica. The interstices are filled with a cloudy mass, apparently fine grains, cemented, as the larger ones, by silica.

Blue-stone, Bigelow Blue Stone Company, Malden, Ulster County.— Minerals: quartz and feldspar. The quartz is in grains which appear to be very angular in shape, more like a breccia. And the grains are clearer than those of the other sandstones examined. And the proportion of quartz grains to the rest of the matter is smaller. The feldspars observed differ very materially from that in the other stone, Several grains of a triclinic feldspar were observed, which were very fresh. Another feldspar is almost completely decomposed. No carbonate of lime appears to be present. and very little oxide of iron. The long, wavy, crystal-like dark spots in the stone appear to be decomposed feldspar, more or less stained with iron. The cementing material is probably silica, as dilute hydrochloric acid has no effect, and is not stained with iron.

Sandstone, Oxford Blue Stone Company, Oxford, Chenango County.— Much like the preceding.

Sandstone, Hughes Brothers, Oswego Falls.— Component minerals: quartz and feldspar. The quartz is in angular grains, and has fluid cavities with bubbles. The more numerous cavities are too small to distinguish the filling matter. Acicular crystals are rarely present. The feldspars are wholly kaolinized, often dirty and discolored from the

permeation of iron. Carbonate of lime also appears to be one of the results of decomposition. The cementing material is chiefly iron, with some carbonate of lime.

Sandstone, Gilbert Brady & Company, Albion, Orleans County.— The principal mineral constituent is quartz. There is, however, much kaolinized feldspar, some granules of hydrous oxide of iron and a "dirty," interstitial matter, probably fine quartz and iron-bearing clay. The cementing material is partly carbonate of lime and hydrous oxide of iron, the latter predominating.

Sandstone, Hulberton, Orleans County.— This stone cannot be distinguished from the Albion, excepting that the former is a little coarser-grained.

Sandstone, Portage Bluestone Company, Portage, Wyoming County.— Minerals: quartz, feldspar, micas (?), oxide of iron. The quartz is filled with minute cavities, holding liquids and gases. It occasionally seems to be porous as the cavities are stained with oxide of iron, which comes from the cementing material. The feldspar is not fresh, but kaolinized, carbonate of lime being one of the resulting products. The mica appears in minute scales. The cementing material is largely carbonate of lime, hydrous oxide of iron being next in proportion. In dilute acid the grains of quartz fell apart generally. Some of the granular carbonate of lime is probably secondary matter from the feldspars.

Sandstone, Olean Bluestone Company, Olean, Cattaraugus County.— Resembles closely the Portage sandstone, except that it is coarser-grained, has more iron, and the few scattering scales of mica (?) are so far decomposed as not to be identified with certainty.

Sandstone, Kibbe, East Longmeadow, Mass.— Constituent minerals are quartz, feldspar and hornblende (?). The quartz is in fine grains and rather free from inclusions. The feldspar is almost wholly decomposed and stained more or less with iron. Occasional crystals of a mineral which looks like hornblende occur. Iron is the principal cementing material.

Sandstone, Maynard, East Longmeadow, Mass.— Cannot be distinguished from the Kibbe stone.

Sandstone, Worcester, East Longmeadow, Mass.— Quartz and feldspar are the constituent minerals. The quartz is cloudy from minute cavities and is more or less stained. The feldspars are almost completely kaolinized. The cementing material is apparently lime and iron. Fibrous mineral abundant.

Sandstone, Brainerd Quarry Company, Portland, Conn.— Quartz, feldspar and occasional scales of decomposed mica, are the constituent minerals. The quartz represents about two-thirds of the bulk of the stone. The grains are angular, and, as a rule, clear. Acicular crystals and included gas pores and liquid are not common. The feldspars are almost all of them completely kaolinized. Carbonate of lime is a resultant mineral of this decomposition. Iron is the chief cementing material, with the carbonate of lime. Some of the feldspars are fresh enough to show the original cleavage lines. The muscovite has lost most of its special properties and appears more like talc There is much interstitial "mud" which seems to be made up of aggregations of iron and fine silica.

Sandstone, Belleville, New Jersey.— No essential difference is noted between this stone and that from Portland.

Sandstone, Berea, Ohio.— Quartz seems to be the principal mineral in this stone. The sole exceptions appear in the yellow spots of hydrous oxide of iron.. The quartz is in fine, angular and even-sized grains, lying in close contact. The stone seem to be friable and imperfectly cemented together. There is no reaction for carbonate of lime.

Sandstone, Bristow, Virginia.— Quartz and feldspar are constituent minerals. The quartz is rather cloudy. The feldspars are almost completely kaolinized. Enough remains to show that they were plagioclase. The cementing material is hydrous oxide of iron and carbonate of lime. A great deal of muddy interstitial matter shows clots of iron.

NOTES ON THE TABLE OF TESTS

The chemical analyses give the percentages of lime and magnesia and of insoluble matters (in dilute hydrochloric acid) in the limestones; and the ferrous and ferric oxides in the sandstones. The ratio of the lime and magnesia in the marbles from Tuckahoe and Pleasantville shows them to be dolomitic. The Sandy Hill and Glens Falls stone do not have enough of the magnesia to be classed with the dolomites. They, and the Gouverneur marbles, are magnesian limestones. Both are remarkable for their high percentage of silica. The others are more or less pure limestones.

The sandstones also are divisible into two classes, determined by the condition of iron in them. In the blue-stone, and the other gray and gray-blue sandstones, the iron exists in them as ferrous oxide and, probably, in combination with the silica as a silicate. The red sandstones are all marked by the presence of ferric oxide, where the iron is in the highest state of oxidation. The Potsdam and Albion sandstones are exceptional, in that they contain remarkably little iron, and that is nearly all in the ferrous condition The amount of iron varies greatly, even in the case of the red sandstones, from 0.80 per cent in the Lake Superior red stone, to 5.26 in the Potomac red sandstone from Bristow, Virginia. Of the state sandstones, that from Oswego Falls has the most ferric oxide — 1.71 per cent. The blue-stones and the sandstones of the Portage and Chemung formation are marked by relatively small quantities of ferric oxide.

The percentage of water absorbed by the dry stone, and the weight of water per cubic foot of the stone, varies in the several classes of stone as follows:

	Per cent of water.	Weight of water. Pounds.
Granites	0.066 – 1.55	0.11 – 2.62
Marbles	0.08 – 0.16	0.14 – 0.27
Limestones	0.07 – 6.17	0.14 – 10.36
Sandstones	0.82 – 18.07	1.40 – 29.54
Slate	0.15	0.26

The larger number of sandstones and limestones, and the few granites and marbles tested, make the comparative capacity for absorption between these classes of stone appear more variable, because of the disparity in numbers being so great. The range in each class is wide, as shown by the table. It will be noted, however, that this variation in the limestones of the state, although large, is not as great as it is in the sandstones. The total range of the table is widened by the great absorptive capacity of the oolitic limestones of the west, which are included in the series. The granites, marbles and the limestones do not absorb so much as the more porous sandstones.

Arranged in the order of water absorbed, beginning with the least absorbent, the sandstones stand as follows:

	Per cent absorbed.
Blue-stone, Bigelow Blue Stone Co., Malden. Ulster county	0.82
Blue-stone, Albert Shear & Co., Duanesburgh, Schenectady county	0.88
Sandstone, Oxford Blue Stone Co., Oxford, Chenango county	1.11
Sandstone, Potsdam Red Sandstone Co., Potsdam, St. Lawrence co.	2.08
Sandstone, Olean Blue Stone Co., Olean, Cattaraugus county	2.12
Sandstone, Gilbert Brady & Co., Albion, Orleans county	2.37
Sandstone, M. Scanlon, Hulberton, Orleans county	2.38
Sandstone (coarse-grained), Brainerd Quarry Co., Portland, Conn	2.68
Sandstone, Portage, Wyoming county	2.87
Sandstone, Warsaw Blue Stone Co., Warsaw, Wyoming county	2.96
Sandstone (fine-grained), Brainerd Quarry Co., Portland, Conn	2.98
Sandstone, Bristow, Virginia	3.46
Sandstone, Hughes Bros., Oswego Falls, Oswego county	3.53
Sandstone (Kibbe), Norcross Bros., East Longmeadow, Mass	4.38
Sandstone (Maynard), Norcross Bros., East Longmeadow, Mass	5.03

	Per cent absorbed.
Sandstone, Belleville, New Jersey	5.32
Sandstone (Worcester), Norcross Bros., East Longmeadow, Mass	5.43
Sandstone, Berea, Ohio	6.80
Sandstone, Portage, Lake Superior, Michigan	8.71
Sandstone, Nova Scotia	18.07

A comparison of the percentage of absorption capacity and the specific gravity of these sandstones, by means of graphic illustration, shows that the absorption, in general, varies inversely as the specific gravity. And there are three groups, indicated by a study of the curves representing these elements. They are:

I.
- Malden blue-stone.
- Duanesburgh blue-stone.
- Oxford blue sandstone.

II.
- Potsdam red sandstone.
- Albion sandstone.
- Olean sandstone.
- Hulberton sandstone.
- Portland, Connecticut, sandstone.
- Portage sandstone.
- Warsaw sandstone.
- Bristow, Virginia, sandstone.
- Oswego Falls sandstone.

III.
- East Longmeadow, Massachusetts, sandstone.
- Belleville, New Jersey, sandstone.
- Berea, Ohio, sandstone.
- Portage, Lake Superior, Michigan, sandstone.
- Nova Scotia sandstone.

The higher specific gravity and lower absorptive capacity of the blue-stones is notable, and accords with a wide experience in their use. The difference between them and the Potsdam and Medina sandstones, which are placed here in the second group, amounts to 1.5 per cent, equivalent to 2.4 pounds of water absorbed by a cubic foot of the stone. In the third group the water absorbed exceeds 4 per cent, and is equivalent to at least 6.75 pounds in weight. The

high percentages of the Berea, Lake Superior red and the Nova Scotia sandstones represent the more porous stones of this series.

The density of the red slate is shown in the large specific gravity and the remarkably low absorption capacity.

The percentage of loss due to the action of carbonic acid gas ranges in the several classes of stone as follows:

Granites	0.002 – 0.029
Marbles	0.004 – 0.023
Limestones	0.008 – 0.087
Sandstones	0.003 – 0.29
Slate	0.004

These percentages are low and apparently insignificant. But it means the removal of so much material, and in the long exposure of years it is cumulative. And it is the removal of the binding material, in some cases, thereby exposing the stone to a more ready disintegration and ruin. Particularly is this true of the sandstones which are held together by lime, or iron oxides, soluble in water, carrying carbonic acid gas. It is notable that the variation in the granites is large, the Hallowell granite showing a loss ten times as much as that of the Au Sable works, at Keeseville, and five times that of the Grindstone Island quarries.

The marbles also exhibit much variation, the loss in the highly crystalline, Tuckahoe and Pleasantville marbles, being one-fifth only of that in the case of the Plattsburgh (" Lepanto ") marble, and one-third that of the Gouverneur. The range in the percentages in the limestones is even greater. In the case of those from state quarries it is between 0.008 and 0.028. The much larger loss in the oolitic limestones of Indiana and Kentucky is significant and indicative of much more rapid wear under the action of carbonated water.

The Potsdam sandstone, Malden blue-stone, Oxford blue sandstone, Belleville, N. J., sandstone, and the Nova Scotia

sandstone average about 0.03 per cent of loss; the Connecticut brownstones and the Massachusetts red sandstones vary from 0.04 to 0.09 per cent. The Portage, Lake Superior, sandstone shows the least action, amounting to 0.005.

The results of the test by means of sulphurous acid gas, which may be analogous to the action of the more vitiated atmosphere of large cities, are somewhat similar to those in the carbonic acid gas test. And the extremes are, in the several kinds of stone, as follows:

Granites	0.007 – 0.024
Marbles	0.12 – 0.25
Limestones	0.065 – 0.25
Sandstones	0.003 – 0.17
Slate	0.07

Keeseville granite loses less than the Hallowell, but more than the Grindstone Island specimen. There is a remarkable difference in the relative behavior of the limestones and marbles as compared with the granites and sandstones, in the amount of loss caused by carbonic acid gas and sulphurous acid gas, respectively. The calcareous stones lose from three to ten times as much in the test with sulphurous acid as in that with the carbonic acid, whereas, the sandstones and granites do not suffer any greater loss. This difference is highly suggestive in its application to constructive work in cities, and indicates the greater capacity of resistance of the latter classes of stone to the action of an atmosphere containing this gas.

The variation in the marbles is less than in the carbonic acid gas tests, and the Glens Falls stone is at the head of the list — while the Tuckahoe and Pleasantville stones lose more. The siliceous Sandy Hill limestone appears the best among the limestones, its loss being least and only one-third of that of the Onondaga gray, and less than half that of the average of the limestones. The Niagara limestone, from Williamsville, shows the greatest loss — 0.25 per cent.

It is notable that the oolitic stones showed a gain of 0.16 to 0.19 per cent, due to the replacement of the calcic carbonate, in part, on the greater area of interstitial surfaces in these more porous stones, by the calcic sulphate formed by the action of the sulphurous acid.

The sandstones exhibit a wide range of loss, amounting to one hundred times as much in the Oswego Falls stone as in the Malden blue-stone. The losses in the Potsdam and the Lake Superior stones also are small. The Berea, Ohio, the Bristow, Virginia and the Warsaw stones are large losers.

The action of the dilute sulphuric acid upon the granites, sandstones and slate was as follows:

	Per cent of loss in weight.
Potsdam sandstone	0.02
Ausable granite	0.06
Red roofing slate, Middle Granville	0.07
Sandstone, Albion	0.08
Sandstone, Hulberton	0.08
Granite, Hallowell, Maine	0.08
Sandstone, Worcester, East Longmeadow	0.11
Sandstone, Bristow, Virginia	0.11
Sandstone, Kibbe, East Longmeadow	0.11
Granite, Grindstone Island	0.13
Sandstone, Maynard, East Longmeadow	0.17
Blue-stone, Malden	0.20
Sandstone, Oxford	0.20
Sandstone, Nova Scotia	0.20
Sandstone, Portland, Connecticut	0.22
Sandstone, Lake Superior, Michigan	0.36
Sandstone, Portage	0.42
Sandstone, Olean	0.44
Sandstone, Berea, Ohio	0.45
Sandstone, Warsaw	0.49
Sandstone, Portland, Connecticut	0.55
Sandstone, Duanesburgh	0.63
Sandstone, Oswego Falls	0.74
Sandstone, Belleville, New Jersey	1.01

The effects of repeated and rapid changes of temperature in alternate freezing and thawing, can be grouped in the class of sandstones, as follows:

I. Unchanged.
   Sandstone, Potsdam.
   Blue-stone, Malden.
   Blue-stone, Oxford.
   Blue-stone, Duanesburgh.
   Sandstone, Albion.
   Sandstone, East Longmeadow.
   Sandstone (coarse-grained), Portland, Connecticut.
   Sandstone, Belleville, New Jersey.
   Sandstone, Bristow, Virginia.
   Sandstone, Nova Scotia.

II. Slight flaws and slight checks.
   Sandstone, Warsaw.
   Sandstone, Olean.
   Sandstone, Berea, Ohio.
   Sandstone, Portage, Lake Superior, Michigan.

III. Slight scaling.
   Sandstone, Portage, Wyoming County.

IV. Chipped.
   Sandstone (fine-grained), Portland, Connecticut.
   Sandstone (Maynard), East Longmeadow, Massachusetts.
   Sandstone (Kibbe), East Longmeadow, Massachusetts.
   Sandstone, Hulberton.

V. Badly checked.
   Oswego Falls sandstone.

Noting the effects produced by exposure to a high temperature (1200°–1400°F.) and sudden cooling, the sandstones, as tested, may be grouped as follows:

I. Strength impaired but little.
   Sandstone, Potsdam.
   Sandstone, Albion.
   Sandstone, Hulberton.
   Sandstone, Portage.

II. Strength not greatly impaired.
   Blue-stone, Duanesburgh.
   Sandstone, Portage, Lake Superior, Michigan.
   Sandstone, Bristow, Virginia.

III. Strenght somewhat, but not wholly impaired.
   Blue-stone, Malden.
   Sandstone (Maynard), East Longmeadow, Massachusetts.
   Sandstone, Oswego Falls.

IV. Badly checked.
   Sandstone, Warsaw.
   Sandstone, Oxford.

V. STRENGTH GREATLY IMPAIRED — STONE GREATLY WEAKENED.
Sandstone, Olean.
Sandstone, Nova Scotia.

VI. STRENGTH GONE — CRUMBLED WITH A BLOW.
Kibbe sandstone, East Longmeadow, Massachusetts.
Worcester sandstone, East Longmeadow, Massachusetts.
Sandstone (fine-grained), Portland, Connecticut.

VII. STRENGTH GONE — CRUMBLED WITH TOUCH.
Sandstone (coarse-grained), Portland, Connecticut.

VIII. STRENGTH ENTIRELY GONE.
Sandstone, Belleville, New Jersey.
Sandstone, Berea, Ohio.

Omitting the lesser distinctions, these results, obtained by the test at a high temperature, may be roughly grouped in two divisions. In the one, where the strength is not wholly impaired, the sandstones of the state are found; in the other, wherein the strength is gone, are: the sandstones of East Longmeadow, Massachusetts, of Portland, Connecticut, Belleville, New Jersey, and Berea, Ohio. Of the stones from the state, it may be noted that the Potsdam and Albion sandstones are in the first group in both the freezing and the heat tests. The compact blue-stones from Malden and Duanesburgh, appear to have suffered a slight loss of strength at the high heat test. The Oxford blue sandstone was checked badly.

The results are not altogether parallel in the two series, as, for example, the Belleville, New Jersey, sandstone, which was unchanged in the freeziug and thawing tests, lost its strength entirely in the furnace heating. The behavior of the Nova Scotia stone was somewhat similar to that from the Belleville. The explanation of these differences is in the structure. Although both of these sandstones are porous and have a relatively large capacity of absorbing water, they are not laminated, but homogeneous, and hence did not show checks or scaling. The specimen of Berea sandstone was laminated, and it checked in freezing and thawing, and was ruined by the high heat test. The conditions of exposure, imitated in these two series of

tests, are not such as to be resisted equally well by all varieties of sandstone, as has been shown in the above notes of the results. And, hence, comparatively few can be found which are durable under ordinary exposure to atmospheric agencies, and are fire-resisting, also. The importance of durability under ordinary conditions is evident at once, and outranks, in all general constructive work, that of fire-resistance, which may be viewed as extraordinary exposure or an accidental condition. The superiority of the better sandstones to the granites, marbles and limestones in their property of resisting the effects of high temperature — fire — is notable and worthy of consideration, and these latter classes of stone are shown by the tests to be unable to withstand the vitrifying and calcining effects of intense heat. Under ordinary weather exposure, as shown by the freezing and thawing tests, they are quite as durable as the sandstones. The ability to resist the action of heat determines the value of a stone for fire-proof construction. But in any fair comparative estimate of the value of the several kinds of building stone — granites, marbles, limestones and sandstones — the considerations of appearance, beauty, ease and economy of working, locality, as well as the conditions of exposure, are important. And no rigid scale of credits or gradations by sharp lines of demarcation are possible.

The results of these comparative tests of the durability of the more common building stones in use in our cities, are indicative of valuable properties in the best stone from quarries in the state and of superiority over those from other quarry districts of the country. New York has within its limits almost inexhaustible deposits of granites, sandstones, limestones and marbles of such superior quality. And for durability, some of its sandstones and blue-stones are the best in the world. The "life" of such stones, or the length of time which they may last, as durable material in buildings, cannot be known from the oldest structures, in which they are still almost as fresh and as strong as ever.

VI

ON THE DURABILITY OF BUILDING STONE AND THE CAUSES OF DECAY

I. Physical Structure — State of Aggregation of the Particles

The physical structure and the chemical composition of stone are so related, and the durability is so dependent upon them, that it is difficult to consider them separately. The rapid disintegration of a coarse-granular and loosely-aggregated stone is hastened if the component grains be readily soluble in water containing acid gases. Conversely, the resistance to weathering agents, in the case of a siliceous stone, is vastly increased when its compact mass is so dense that there are no interstitial spaces into which water can penetrate rapidly. The points of attack are lessened by the closer aggregation of the crystals or grains. So intimate is this relation of structure and composition that the defects of the one class are not offset by the advantages of the other, and these defects impair seriously the value of a stone — the ideal structure is counterbalanced by wanting strength of chemical constitution.

The physical structure is of importance in the two great classes of stone, the crystalline and the granular or sedimentary; although in the latter class the results of defective or wanting constitution are, perhaps, sooner apparent than they are in the former — crystallines.

I. Sedimentary or granular rocks or stone. — The size and arrangement of the grains are here considered. It is evident that the size of the grains determines to some extent the interstitial spaces and the porosity of the mass, inasmuch as the coarser-granular varieties leave larger spaces,

unless they are filled by finer material. The more open and loosely-aggregated the mass, the more porous the stone, and the greater the volume of water, carrying dissolving agents, which can be absorbed, and the larger the surface area which can be attacked by them. The arrangement of the grains also favors or prevents the ingress of these attacking forces. For example, a laminated structure, with its planes along which the flow of moisture or water is facilitated or is easier than in other directions, helps the tendency to exfoliation, or the scaling off of thin sheets and laminæ. On a larger scale the arrangement of rocks is seen in beds and the movement of subterranean waters is along their bedding or jointage planes. Where the mass is more closely interwoven, as it were, the saturation, although equally great in volume, is not onward flowing in given planes and increasingly active, and there are no lines of weakness along which the disruptive forces can act so readily. The ideal of strength of structure is that wherein the grains are in close contact, and they are of varying sizes, filling all the space, as in such an arrangement no planes of splitting, and, hence, exfoliation, are possible, without cutting across the grains themselves. Hence the density which is observed in some of the conglomerates, where the spaces are well filled by a strong, siliceous cement. All rocks are, however, more or less porous. The particles are not everywhere in actual contact, and there are spaces of greater or less extent between them. The most dense and compact limestones and sandstones, and the crystalline granites and marbles as well, have such interstices. And, in general, the specific gravity is indicative of the degree of porosity in stones of a given class, that is, in sandstone, as compared with sandstone, or granite with granite. It will be understood that the specific gravity of the particles or mineral species composing the rock mass, determines that of the stone. Thus quartz has a specific gravity of 2.65, whereas hornblende and pyroxene rise to 3.3–3.5, and, hence, the specific gravity is

determined largely by the minerals which make up the mass. The more porous a rock the greater the interstitial space, and the greater its capacity for absorbing water, or its absorptive ratio. As a rule, the more porous stone is less valuable as a durable building material.* The relation of porosity to specific gravity is shown in the several classes of building stone in the following table, wherein are given: first, the locality; second, the specific gravity; third, the percentage of water absorbed, or the absorptions percentage, and, lastly, the computed pounds of water absorbed by a cubic foot of the stone.

Stone.	LOCALITY.	Specific gravity.	Percentage of water absorbed.	Pounds of water absorbed per cubic foot.
Granite......	Grindstone Island, Jefferson Co....	2.714	1.55	2.62
Granite.....	Ausable Forks, Essex Co..	2.755	0.066	0.11
Granite......	Hallowell, Maine..........	2.655	0.34 0.41	0.56 0.68
Marble.......	Tuckahoe, Westchester Co........	2.868	0.14	0.25
Marble.......	Glens Falls, Warren Co............	2.718	0.08	0.14
Marble.......	Gouverneur, St. Lawrence Co......	2.756	0.16	0.27
Limestone...	Sandy Hill, Warren Co............	2.764	0.14	0.24
Limestone...	Onondaga Reserv., Onondaga Co..	2.708	0.14	0.24
Limestone...	Chaumont, Jefferson Co...........	2.715	0.07	0.12
Limestone...	Prospect, Oneida Co..............	2.725	0.14	0.24
Sandstone..	Potsdam, St. Lawrence Co.........	2.604	2.08	3.37
Sandstone..	Oxford, Chenango Co.............	2.711	1.11	1.87
Sandstone..	Malden, Ulster Co.	2.751	0.82	1.40
Sandstone..	Albion, Orleans Co...........	2.599	2.37	3.84
Sandstone..	Warsaw, Livingston Co............	2.681	2.96	4.95
Sandstone..	East Longmeadow (Kibbe), Mass...	2.480	4.33	6.69
Sandstone..	Portland, Conn...................	2.622	3.07	5.02
Sandstone..	Portland, Conn. (coarse-grained)...	2.635	2.60	4.27
Sandstone..	East Longmeadow (Worcester).....	2.490	5.48	8.51
	Caën limestone........	1.839	16.05	

In this table we note that the granites range in specific gravity from 2.65 to 2.71; the marbles 2.70 to 2.86; the

* "Other things being equal, it may probably be said that the value of a stone for building purposes is inversely as its porosity or absorbing power."—T. S. Hunt, Chemical and Geological Essays. Boston, Mass., 1875, p. 164.

limestones 2.70 to 2.76; the sandstones 2.48 to 2.75. The absorptions percentage in the several classes is as follows:

Granites	0.066–1.55.
Marbles	0.08 –0.16.
Limestones	0.07 –0.14.
Sandstones	0.82 –5.48.

The greater absorbing capacity of the sandstones as compared with the crystalline granites and limestones is apparent in this table. And a granular structure is generally more porous than a crystalline one, and less able to withstand the action of frost.*

In the crystalline stones the structural arrangement is important because of the diversity in the mineralogical species. It may be well illustrated by reference to granite and gneiss, which differ in the arrangement of the minerals only. But this difference is a radical one in a consideration of use as a building material. The parallel lines in the foliated, gneissoid rocks, or the layers of feldspar, quartz and mica, afford easy-splitting planes and ready access to moisture. The rate of alteration and decay varies, and this unequal destruction of the mass lets down the more enduring minerals and layers. Hence, as a rule, the granites are more durable than the foliated rocks — as gneisses and mica schists. The greater uniformity in the size of the crystals also contributes to the strength of the stone.

* The volume of water absorbed, when relatively large, increases the dampness, requiring an increased consumption of fuel for its evaporation and, what is of far greater importance, contributes to the injurious effects of alternations of heat and cold, by freezing and thawing. In order to get a more impressive conception of the amount of water which can be absorbed, assume the case of an ordinary brownstone front. Then, given a height of fifty feet and a stone veneering eight inches thick, the total weight of water which a saturated condition would represent in the several varieties of sandstone, Potsdam, Medina, East Longmeadow and Connecticut brownstone, would be as follows:

Potsdam	1,685 pounds.
Medina	1,920 "
East Longmeadow	4,255 "
Portland, Connecticut	2,510 "

or, in general, between three-quarters and two tons, nearly.

The coarsely-crystalline stones are more liable than the finer-crystalline to be injured by the decay and falling out of the less enduring micas and hornblendes. The disposition of the constituent crystals in any given stone also affects its strength. The interlocking of crystals gives strength, as in any woven texture the closer the threads of woof and warp the greater the resistance to rending.

II. Chemical Composition

The durability of building stones is indicated by their chemical composition, both in the cystalline and the non-crystalline, or sedimentary groups. And the nature of both the grains and the cementing material is to be considered. The latter may be such as to be readily acted upon by atmospheric elements, and the stone fall to pieces as a heap of quartzose sand, each grain of which, by itself, would have resisted for ages. Without the bond the tottering wall gives away. The principal atmospheric agents which attack stone, are carbonic, hydrochloric, nitric and sulphuric acids, ammonia and several organic acids. These agents, carried by rain water, act by solution, oxidation, deoxidation and hydration and the constituent minerals as well as the cement are affected by them. And the durability of any given stone is determined by that chemical constitution which is least liable to change under their action.

In the crystalline rocks the varying degree of solubility of the several minerals is indicative of the strength of resistance, which may be offered, and of the enduring property of the mass. A siliceous rock, other things being equal, is the most durable. The silica must, however, be in a compact and well cemented form, as in quartzite, and not in the shape of a loosely coherent sandstone. Argillaceous or shaly stones are inferior in quality on account of both physical structure and chemical weakness. For the same reason limestones containing clayey seams, and sandstones with

shaly cement, are inherently weak. The ferruginous or iron compounds are all more or less easily attacked, and when, as in the case of many sandstones, the cementing material is such, its presence is of importance in a consideration as to durability. The ferric oxide cannot take up more oxygen, and is, therefore, preferable to the ferrous compounds. The sulphides are susceptible to change in the long exposure to the air. The nature of the mineralogical species in the case of the sulphides has, however, much to do with the rate of decay, the pyrite being more durable than the marcasite.*

Calcareous compounds, particularly the carbonates, are dissolved readily by water, carrying carbonic acid gas, and hence the pure limestones are comparatively short-lived. The magnesian carbonate is less soluble, and as a rule, the magnesian and dolomitic limestones and marbles are more durable than the purely calcareous stones.†

As there is a wide range in the ease with which the more common minerals of the crystalline rocks are attacked or in their rate of alteration and decomposition, the same is true of the various granites, granitoid rocks, gneissic and other crystalline stones in whose composition they enter, and which are used in construction work. The feldspars vary greatly in their ability to resist atmospheric agencies, which tend to their kaolinization and destruction, as is evident in the unequal weathering of granitoid rocks under apparently similar conditions. The more highly ferruginous micas, hornblendes and pyroxenes are apt to decay more rapidly than those containing less iron. Pyroxene, as compared with hornblende, also is more liable to change.

* A. A. Julien, United States Tenth Census, Report on Building Stone.

† "As a general rule, however, the magnesian limestones, in their normal condition are more friable and more porous and less firm in their character than the pure carbonates of lime. * * * The more porous limestones and some of the marbles, which notoriously lack cohesive power, may be more affected by this action." Prof. James Hall, report on building stone. 39th Annual Report New York State Museum, Albany, 1886, p. 210. (Communicated to Capitol Commissioners in 1868).

The mineralogical composition representing the chemical nature of the stone is, therefore, of the first importance in a consideration of its durability for building purposes. And for the granites a safe generalization is a relatively high percentage of silica, as quartz (or an acidic granite) with unaltered, orthoclase feldspar and a comparatively small amount of the lighter-colored hornblendes and micas. In the marbles the dolomitic and highly-crystalline varities are to be preferred to the purely calcareous stones.* In the limestones the more siliceous varieties and those in which the magnesia and lime are found in the proportions of a true dolomite, represent the more durable kinds. The sandstones vary much in the nature of the cementing material, and they are graded, according to their chemical composition, into siliceous, argillaceous, ferruginous, micaceous and calcareous varieties. The siliceous bond is the best, wherein the mass approximates to a quartzite in its composition. The others are to a greater or less degree liable to decay through the solution of their cement.

III. Accident of position — in use

In this section the consideration of the properties inherent in stone, due to their position in their natural *habitat* — the quarry, is omitted, although its importance is recognized. We take it from Nature's great building for the construction of our edifices. Reference, however, may be made to the weathered rocks of the surface, the altered laminæ of beds standing on edge, the shattered condition of highly folded and faulted strata, the metamorphosed nature of the rocks of volcanic districts, and the glaciated and polished out-crops within the limits of the continental glacier. In these cases Nature is a great teacher, and her object lesson, so easily

* The rapid wear and destruction of some well-known marbles is explained by the mixture of calcareous with dolomitic grains and the disintegration, by the solution of the former — thus breaking down the mass.

read, is before us. In building, the horizontal position of the bedded stone is of greatest importance. That is, the stone should be laid on its bed, and not on edge.* Improper position in the wall, where it is exposed to the weather, has more to do with the disintegration and decay of building stone, than the chemical composition, and, in many cases, it is more effective than the inherent weakness in its physical structure.

In New York, and in the smaller cities of this state, the common practice is to pile the stone up edge-wise, making a veneer, as it were, of stone. The use of granites, marbles and limestones in this way would not be so reprehensible, especially in stones which are massive and without lamination. In practice, however, it is the bedded rocks and the sandstones which are thus laid on edge. The brownstone of Connecticut has been, almost without exception, subjected to the more effective action of the atmospheric agents, through this faulty system of erection. The varying nature of the material for any great thickness, and the oblique lamination and cross-bedded structure, so common in sandstones, occasion the exposure of material of unequal hardness, and consequent unequal weathering, when the stone is dressed or smoothed to a plane surface, and is set on edge in the wall.† In the case of the Connecticut brownstone this variation yields wavy lines in the the rubbed surfaces, which are a pleasing relief to the eye in material of so sombre a shade of color. But when it is recognized as associated necessarily with elements of weakness, the cultivated sense of beauty is offended. The scaling or exfoliation of large sheets, due to the action of infiltrating water and frost, is evident after exposure for a few years, or, at most, of two or three decades, and the result is an unsightly front. Longer exposure tends to the breaking down of the

* Not, necessarily, as in the quarry, as it may there have been tilted and on edge.

† Report on Building Stone, by Prof. James Hall, 39th Annual Report N. Y. State Museum, Albany, N. Y., pp. 205–6.

whole block, and the complete destruction is a question of time, so that the *life* of our brownstone front scarcely exceeds that of its well-preserved owner. Near the earth this scaling proceeds more rapidly, as can be seen in all structures where stone is so placed. The exposure to extremes of temperature and an excess of moisture, both in the melting snows, which are often piled against these lower courses, and that arising from the ground, when not stopped by a damp course, appears to be the cause for this more rapid decay. Another cause of decay is in the faulty construction of walls, wherein no provision is made, by undercut mouldings to carry off the drip of the water, and by inclined surfaces, in the case of lintels and sills, so that it cannot saturate the stone. The proper position, even when the sills, lintels and water-tables are laid on their bed, does not protect thoroughly, if there are horizontal surfaces where the water cannot drain off freely and quickly. Polished surfaces add to the strength in position, by conducing to a more rapid drainage of the rain waters, than do the natural surfaces of quarry-face stone or the uneven ones of rough-dressed blocks. They have no little hollows into which the waters can collect, and so act upon the stone up to the point of a saturated solution. The ancient Greek structures, of polished Pentelic marble, and the palaces of the Lombards, in northern Italy, are evidence of the durability of smoothed and polished surfaces. The old Gothic builders also appreciated the importance of smooth surfaces, as well as a proper position in the wall. The glaciated ledges of our rock outcrops, which shed the water rapidly, show the value of such a surface for endurance.*

* "A smooth and sound rock surface, produced by glacial rubbing and polish, is better adapted to endure the ravages of time than any artificially hammered surface." — Dr. Robert Bell, Bull. Geol. Soc. of America, Vol. 1, p. 306.

CAUSES OF DECAY

With Notes of Observations

The causes of decay have been noted incidentally in the section on the durability of building stone. Their further consideration may be illustrated by references to examples in construction and to outcrops of rocks in which the phenomena are well exhibited.

The agents causing decay are physical and chemical.

I. Physical Agents

This group includes:

1. Heat (and cold) — expansion and contraction.
2. Mechanical abrasion, by water and by wind.
3. Growing organisms.

Climate and situation are factors of importance in a consideration of the effects on building stone of variations in temperature. In the dry air and less range of temperature in Egypt, the coarse crystalline granite (syenite) retains its smooth and even polished surface for centuries; in our less equable climate, and alternately dry and humid atmosphere, the same stone scales after an exposure of a decade of years. The marble structures of ancient Attica, the well-preserved monuments of ancient Rome, in fact, of all the drier climates of the Mediterranean basin, are, to-day, in so good a state of preservation, not so much because of inherent differences in the stone, or even in its use, as in the absence of extreme degrees of frost.* The situation, also, is of im-

* The sculptured figures in the white, Pentelic marble of the columns and arches in Rome are still well preserved, because of the pure and smokeless atmosphere as well as by absence of extremes of temperature.— Hull, Building and Ornamental Stones London, 1872, pp. 128–9.

portance. Exposure to the direct rays of the sun produces a greater variation of temperature than that on north or shaded sides of buildings. The range of temperature in our northern states is comparatively great and subject to sharp and frequent fluctuations. Stone has not a high conductive power, and, generally, little elasticity. In the sedimentary rocks the grains are, in most cases, uniform in the nature of material, but in the crystalline rocks there is more generally an aggregation of minerals of diverse species, each of which has its rate of expansion. The coefficient of expansion in the case of quartz, for example, is much greater than it is in orthoclase feldspar and hornblende; calcite is much less than that of dolomite. This unequal rate of expansion, where the range of temperature is great, tends to the production of slight fractures and interstices, into which moisture and air can penetrate, and the strength of the crystalline mass is, no doubt, impaired in time by many alternations of heat and cold, and the consequent expansion and contraction to which it is subjected. As is well known, some of the granites fly to pieces more quickly when subjected to a high temperature than the sandstones. The cause may be in this differential rate of expansion. The failure of granite, in the great Boston fire, is a notable example of the unequal tension and the consequent destruction, in case of intense heat.* The tests reported in the table show the disastrous effects of heat on granites as compared with sandstones of even grain.

Held together by their cohesive power, the individual blocks of stone expand as units, and stone structures of large size, no doubt, also deviate from a normal, according to the degree of heat. Thus the rate of expansion for granite is .000004825 inch per foot, per degree of F.; that of marble,

* The great fire of Boston, like that of Chicago, was an extraordinary test, and the heat was more intense than that of a lesser fire, and no stone withstood it successfully. Neither sandstone nor even common building brick can stand up in a blast furnace.

.00000568 inch per foot, per degree F.; that of sandstone, .000009532 inch per foot, per degree F. For example a sandstone block, ten feet long, would in the change from 30° below zero to 100° F. above zero, be lengthened .15 of an inch. The mere alteration in volume might not alone work serious injury, but aided by moisture it becomes a most active agent, and the effects of expansion and of water cannot be well disassociated and defined in quantity. The force exerted by freezing water is well known, and a common phenomenon in breaking the strongest material. An elementary example may be cited here — the bursting of quartz-crystals which contain liquid inclusions — or, as commonly stated, bubbles of water. At quarries where porous stones are raised, and particularly sandstones, the practice of "seasoning" the stone, that is, of letting the moisture in it —"quarry water"— dry out before use, is another common example, illustrating the influence of frost. Cases where unseasoned or "green" stones have been suddenly cracked and shattered badly, in cold weather, are too common to cite them.

Applying these generalizations to the several classes of building stone, it may be stated that the effects of frost are exerted along the weaker lines, and hence stones which have a laminated, schistose structure are the most liable to be affected. The scaling or exfoliation, so common in some of our sandstones, is due in great part, to the force of freezing water, and it is most apparent where the conditions favor the ingress of the water and where the position, also, allows of a movement of the outer film or layer—scaling, as in the stones set on edge in an outer wall — the frost acts as a wedge, splitting the stone. Results, as serious, are seen in the granular rocks, whose binding material is readily soluble. The dissolving and disruptive forces of water here unite and, to some extent, the mechanical or abrading force also. Some of the Nova Scotia sandstones in New York city are badly weathered in this way. The worst sufferer from the effect

of heat and cold in New York, has been the brownstone, and mainly through improper position. The results are chargeable to the architect and builder rather than to the stone.

The crystalline rocks also suffer by frost, and reference may be made again to the obelisk in New York, whence have fallen many pounds of spalls or fragments forced off by the frost.*

Where the stone is homogeneous and close-grained, and lacks the laminated or schistose structure, it is better able to resist disintegration by frost action. As already stated, the greater the porosity and the more open-grained the stone, the more water it can absorb, and the greater the force which the frost can exert. It is however to be borne in mind that a stone may be so coarse-grained and open as to shed quickly its water and dry without damage from freezing, as a sandy soil may dry sooner and not be frozen to the depth of a clayey and compact layer. In our climate the action of snow is apparently more damaging than rain, as it facilitates the saturation of the stone, and the alternations of freezing and thawing are perhaps more frequent and more severe. Especially is this the case near the ground, and where the melting snow lies against the foundation. In a higher and colder latitude, where the snow may act as a protective covering against excessive cold, and the stone be kept comparatively dry, except for a short period in the spring and autumn, this action may be slight. As in the case of wood the decay is most rapid near the water-line and not under it; so in that of stone, the greatest damage is where there is the widest range and most frequent alternation of heat and cold, and of wet and dry conditions.

The mechanical abrasion by rain water is an effect which cannot be measured in actual cases, but it is a factor in the

* "So too, the obelisk of Luxor had stood for forty centuries in Egypt without being perceptibly affected by that climate. * * * As the result of but forty years of exposure (at Paris) it is now full of small cracks, and blanched, and evidently will crumble to fragments before four centuries have passed." A. A. Julien, United States Tenth Census, Vol. v, p. 370.

destruction of stone. The patter of the rain upon the soil and the erosion by running waters, sculpturing the face of the earth, are familiar phenomena to all. It also is helped by the dissolving property of the water, and the minute exposed projections of the surface are sooner or later loosened and carried away by the rain or the flowing currents of the little rivulets, which collect in the more rapid dashes of our thunder-storms. Some of the more friable limestones and marbles are examples of such combined action of the dissolving and denuding rain. The little structures reared by man are thus exposed to the same forces as the gigantic cliffs and mountains about him, all of which are being carried slowly but surely down to lower levels and to the ocean.

Perhaps equally potent as the water, but not so generally recognized, is the action of the wind, carrying sand,— greater or less, according to its velocity. On the seashore and in exposed situations it is noticeable in the eroded sand hills and cliffs. One of the most remarkable cases can be seen in the dolomitic limestones of Dutchess county, near Dover Plains, where the wind has sculptured the rocks in fantastic forms over areas of several acres in extent. The ground glass in the windows of some of the older houses at Nantucket is an example of wind work — natural sand blast. The wind drives not only the sand, but the rain also, and that into every seam and joint, and penetrates often the whole thickness of a wall, thus aiding the solvent action of the rain-water. And, hence, the wear of the stone is greatest on the sides of the prevailing winds. In New York city, in the older churchyards, monuments are seen smoothed on the windward side and the lettering effaced.

Growing Organisms.— Confervæ, algæ, lichens and mosses all thrive more or less upon ledges of rocks in favorable situations. The effect of their growth on stone in a building is not altogether settled.

We know that some of our hardest and apparently inde-

structible rocks, as the siliceous conglomerates of the Shawangunk mountains, and where there are no evidences of surface decay, are yet covered with lichens. It is possible that there is no effect here.* It is well known that certain rocks are suited to certain species of mosses, and a more vigorous growth is a mark of some kinds of stone. The green confervæ, so often seen in damp weather upon more porous stones, are indicative of moisture and of greater absorptive capacity. As it disappears with the season, and has almost no hold on the stone, its effect must be slight. It is rather an index of a porosity, and of a consequent tendency to decay, through the action of water and frost. Where the mosses thrive there will be some accumulation of dust and a lodging place for spores and seeds of plants, whose rootlets can do harm in the case of inferior stone. And this growth in turn favors the further accumulation of material in which it may continue to thrive. In nature the ledges of softer and more porous stone exhibit the growth of confervæ, whereas the lichens thrive upon the harder and more compact rocks.†

The fungi, from their more penetrating power, may do injury, as in their causation of decay and rots in the case of wood.

II. Chemical Agents

The chemical agents are the following:

1. The solvent action of waters carrying carbonic, sulphuric, nitric, hydrochloric and organic acids.

2. The oxidizing and deoxidizing action of the air, in the presence of moisture.

* "When firmly established, lichens seem to exercise a protective influence against the ordinary causes of decomposition of the stone upon which they grow." Gwilt, Encyclopedia of Architecture, London, 1867, p. 456.

† "None of the softer rapidly decaying rocks produce this vegetation." Prof. James Hall, 39th Annual Report New York State Museum, Albany, 1886, p. 218.

3. The hydration produced in the case of the iron oxides and anhydrous minerals.

4. The action of sulphurous acids in the air.

The action of carbonated waters, in dissolving mineral matters of rocks, is one of the best known facts in chemical geology. And the extent to which some limestones, and even crystalline rocks are weathered, bears witness to its energy. In the laboratory it is possible to imitate nature by subjecting specimens to this test. Carbonate of lime and oxide of iron, which are often the cementing matter in a stone, are particularly susceptible of solution by rain-water containing some acid.*

The kaolinization of the feldspars is another form in which the solvent action of water is exhibited. This phase of decomposition is common in nature, and the kaolin beds are results of this decay. More observations on its occurrence in our granite structures are wanting, owing to the short periods which they have stood exposed in our climate.

Careful microscopic examinations would doubtless prove its progress in existing structures.

The oxidation of pyrite and magnetite, and of the ferrous compounds of iron, is often attended with serious results, and nearly always produces discoloration and makes a stone unsightly.† In the case of magnetite, the oxidation process results in the production of a ferric oxide, and yellowish or red stains and spots which disfigure the stone. As in the case of the pyrite, there appears to be some variation in the tendency to oxidation, and the presence of magnetite is not always absolutely injurious or liable to cause decay and mar the beauty of the stone. Examples of stained and spotted stone, due to oxide of iron, are so com-

* The tests referred to on pages 367, 368 show the extent to which the several classes of building stone are affected, when subjected to the action of carbonic acid gas.

† When the pyrite is in fine crystals and distributed uniformly, the oxidation may produce a mellowing tint and pleasing effect, as in some of the Ohio sandstones.—Merrill, Building Stone, p. 337.

mon as not to need references. The proto-silicates of iron, also, are affected by oxidation and result in persilicates. In general, the iron compounds may be said to rust through the oxidizing agency of the atmosphere. Inasmuch as in our buildings the stone is fully exposed to the action of the rain-water, the effect of oxidation is at a maximum, and greater than in the ledges and out-crops, and also greater than in the quarry.*

The deoxidation is exceptional and is rarely seen in walls above ground. It may go on in foundations and in submarine structures.

Hydration occurs in the case of minerals which are anhydrous, and they absorb water from the air. Brown hematite is an example of a hydrated iron-oxide. The production of this oxide of iron, or ochre, is common in the weathering of rocks. And its occurrence in building stone may be due in many instances, to the oxidation and hydration of pyrite, magnetite or other iron minerals. Owing to the degree of change, there are stages in the progress to complete hydration, and several compounds — between the ferrous oxide and the hydrated ferric oxide.

The action of these several agencies upon building stone is not generally limited to a single one, nor separate from those which act mechanically. The wind and rain, frost and heat ; the dissolving, oxidizing and hydrating action of the atmospheric air, are so interlocked that it is impossible to determine and define the effect of each one. They combine in the work of decomposition and disintegration, and tend to level in the dust the structures which man raises and which he fondly hopes can resist them. But change, that law of our material world, is stamped on what he builds.

" For the stateliest building man can raise is the ivy's food at last."

---

* Bischoff, Chem. and Phys. Geol., Vol. iii, p. 60.

INDEX

MAP

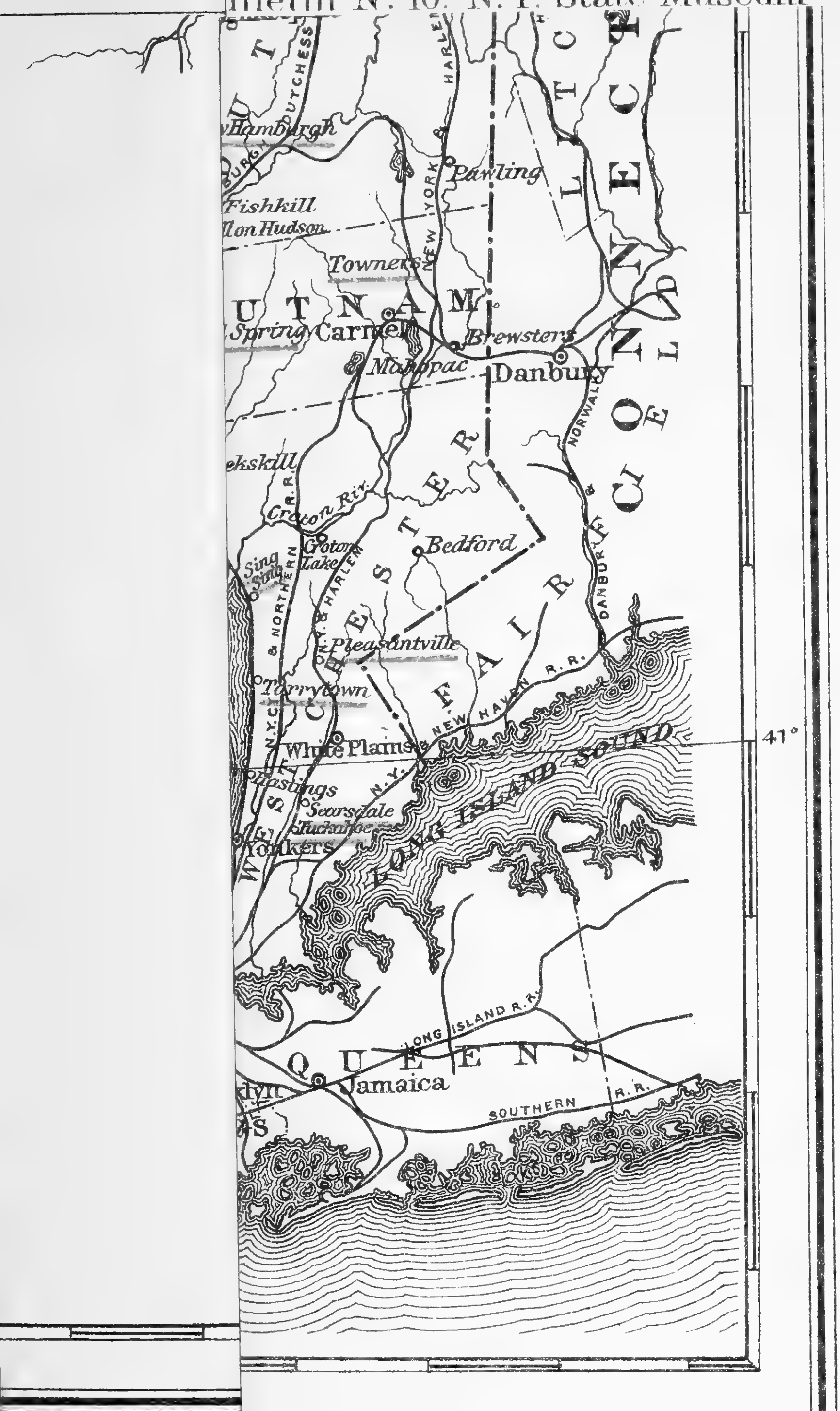
Explanatory Notes

The map which accompanies this report on building stone is on a scale of fifteen miles to an inch. In the absence of colors, exhibiting the geological formations and their limits, it is impossible to show the quarries of the various geological horizons, as the Potsdam sandstones, Trenton limestones, Lower Helderberg limestones, etc. The number of quarries in some of the quarry districts is so great, and they are so close, that they cannot be indicated by appropriate signs on a map of this scale. Hence, in some cases, the localities alone are given. Thus West Hurley and Phœnicia, in Ulster county, stand for groups of openings in the blue-stone territory of the Hudson river; Reservation, near Syracuse, for the Onondaga gray limestone quarries; Medina, for the quarries in that vicinity, etc. The quarry localities are distinguished by red lines drawn under their names.

Many small and comparatively unimportant quarries, which are worked occasionally for private use or at long intervals only, are not given on the map — nor referred to in the report. Stone for building can be quarried at so many points that a geological map, with the rock outcrops shown by appropriate colors and signs, is necessary to exhibit the natural resources of the State in stone for constructive work.

The map shows the geographical distribution of the important groups of quarries, and their location with reference to the cities and markets of the State, and the lines of canals and railroads and natural waterways, whereby they are reached.

It may be noted here that the development of openings has been along these lines of communication, and near the cities, as for example, along the Hudson–Champlain and Mohawk valleys, and the Erie canal.



JULIUS BIEN & CO.


MAP
OF
NEW YORK
SHOWING LOCATION OF QUARRIES
1890.
SCALE IN MILES
SCALE IN KILOMETERS
NOTE.
Red lines drawn under town names indicate the locations of quarries and quarry districts.
Vermeule & Bien
Civil & Mining Engineers.
LAKE ONTARIO
LAKE ERIE
PENNSYLVANIA
NEW JERSEY
VERMONT
MASSACHUSETTS
CONNECTICUT
CANADA
JULIUS BIEN & CO PHOTO LITH

UNIVERSITY STAFF

Executive Department

MELVIL DEWEY, M. A. (Amherst)	Secretary
ALBERT B. WATKINS, M. A. (Amherst), Ph. D.	Assistant Secretary
FRANCIS J. CHENEY, M. A., Ph. D. (Syracuse)	School Inspector
ASA O. GALLUP, B. A. (Yale)	Report Clerk
ELIZABETH A. MORROW	Stenographer
MARTHA J. RICE	Financial Clerk
E. MAUD SANDS	Statistics Clerk
JOHN GARDINIER	Messenger
WILLIAM H. CARROLL	Page

Examinations Department

ALBERT B. WATKINS, M. A. (Amherst), Ph. D.	Assistant Secretary
RALPH W. THOMAS, B. A. (Colgate)	Chief Examiner
JOSEPH W. ELLIS, M. A. (Wesleyan)	Examiner in Science
MARY SALOME CUTLER (Mt Holyoke)	Examiner in Library Science
VERLISTA SHAUL, B. A. (Vassar)	Examiner in Languages
ANNE E. MORSE, B. A. (Cornell)	Examiner in Classics
ELIZABETH L. FOOTE, B. A. (Syracuse)	Examiner in Mathematics
THALIA LAMONT	Examiner in History and Civics
AUGUSTA L. BALCH	Examiner in Drawing
Mrs IDA G. MCMILLAN	Examiner in Preliminary Studies
ADELE B. ALEXANDER	Record Clerk
ISABEL LAMONT	Assistant Record Clerk

State Library

MELVIL DEWEY, M. A. (Amherst)	Director
S. B. GRISWOLD	Law Librarian
GEORGE R. HOWELL, M. A. (Yale)	Archivist
WALTER S. BISCOE, M. A. (Amherst)	Catalogue Librarian
DUNKIN V. R. JOHNSTON, M. A. (Hobart)	Sub-Librarian
HARRY E. GRISWOLD	Sub-Librarian (Law)
NINA E. BROWN, M. A. (Smith)	Shelf-Lister
ADA ALICE JONES	Cataloguer
FRANK C. PATTEN	Curator of Catalogue
MAY SEYMOUR, B. A. (Smith)	Classifier
FLORENCE E. WOODWORTH	Cataloguer
Mrs MARY WELLMAN LOOMIS, M. A. (Lenox)	Accession Clerk
JUDSON T. JENNINGS	Page
MURRAY DOWNS	Page (Law)
JOSEPH O'BRIEN	Page
WILLIAM SCHAENEMAN	Page

State Museum

JAMES HALL, M. A. (Rensselaer Polytechnic) LL. D. (Harvard)	Director, State Geologist and Paleontologist
CHARLES H. PECK, M. A. (Union)	State Botanist
J. A. LINTNER, Ph. D.	State Entomologist
JOHN C. SMOCK, M. A. (Rutgers), Ph. D. (Lafayette)	Economic Geologist
F. J. H. MERRILL, Ph. D. (Columbia)	Assistant State Geologist
JOHN M. CLARKE, M. A. (Amherst)	Assistant Paleontologist
WILLIAM B. MARSHALL, M. S. (Lafayette)	Assistant Zoologist
PHILIP AST	Lithographer
MARTIN SHEEHEY	Messenger
JACOB VAN DELOO	Clerk

State Museum Bulletins

Any of the Museum publications will be sent postage paid on receipt of the nominal price affixed, which covers only a part of the cost.

Volume 1

No. 1. Not yet printed

No. 2. Peck, Charles H. (State Botanist). Contributions to the botany of the State of New York. 66 p. 2 pl. (47 fig.) May 1887. Price 15 cents

No. 3. Smock, John C. (Economic Geologist). Building stone in the state of New York. 152 p. March 1888. Price 30 cents

No. 4. Nason, Frank L. Some New York minerals and their localities. 19 p. 9 diagrams. August 1888. Price 5 cents

No. 5. Lintner, J. A., Ph. D. (State Entomologist). White grub of the May beetle. 31 p. 5 fig. November 1888. Price 10 cents

No. 6. Lintner, J. A., Ph. D. (State Entomologist). Cut-worms. 36 p. 28 fig. November 1888. Price 10 cents

Volume 2

The first six bulletins are each paged independently. The numbers of volume 2 are paged continuously as a single volume.

No. 7. Smock, John C. (Economic Geologist). First report on the iron-mines and iron-ore districts in the State of New York. 4+70 p. map, 58×60 cm. June 1889. Price 20 cents

No. 8. Peck, Charles H. (State Botanist). Boleti of the United States. p. 71–166. September 1889. Price 20 cents

No. 9. Marshall, Wm. B. (Assistant Zoologist). Beaks of unionidæ inhabiting the vicinity of Albany, N. Y. p. 167–189. 1 pl. (18 fig.) August 1890. Price 10 cents

No. 10. Smock, John C. (Economic Geologist). Building stone in New York. p. 191–400, map 58×60 cm., table. September 1890. Price 40 cents

Memoirs

Quarto, uniform with the Paleontology.

No. 1. Beecher, Charles E. (Consulting Paleontologist) & Clarke, John M. (Assistant Paleontologist). Development of some Silurian brachiopoda. 95 p. illus. 8 pl. October 1889. Price 80 cents